

McEglin

BULLETIN of the American Association of Petroleum Geologists

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WALLACE EVERETTE PRATT
Sidney Powers Memorial Medalist
1945

BULLETIN
of the
**AMERICAN ASSOCIATION OF
PETROLEUM GEOLOGISTS**

MAY, 1945

PRESENTATION OF FIRST SIDNEY POWERS MEMORIAL
MEDAL AWARD¹

A. RODGER DENISON²
Tulsa, Oklahoma

For more than a century geologists have been thinking and writing of the geological features associated with oil accumulation. Forty-five years ago the United States Geological Survey published its first studies of the geology of oil fields. Geological departments in oil companies starting around 1910 became universal practice by 1920. The large influx of geologists into petroleum work led to the founding in 1917 of what is to-day the largest group of geologists in the world—The American Association of Petroleum Geologists.

During these many years that geologists have applied their knowledge in finding oil, there have been many men who by their contributions to the art of oil finding have steadily reduced the hazard inherent in the search for these accumulations, and have greatly enlarged the known deposits. Until very recently, however, there existed no honor which recognized excellence and outstanding achievement in Petroleum Geology. It was the recognition of this condition that led in 1943 to the establishment by the Association of the Sidney Powers Memorial Medal Award.

This award is in recognition of distinguished and outstanding contributions to or achievements in Petroleum Geology. Eligibility for the award is extremely broad, there being no limitations with respect to membership in the Association, nationality, or otherwise. Under these broad rules, it is even possible for a scientist of some other profession to receive the award. The criteria are solely the quality and quantity of the contributions or achievements. We have, then, in this award the highest honor which can be bestowed by the profession of Petroleum Geology.

At this point I desire to turn the proceedings over to the man who, more than any other individual, is responsible for this award. His ideas for an award were the basis of the rules eventually formulated and his financial support guaranteed the success of the fund. He will introduce the first recipient. Mr. E. DeGolyer.

¹ Thirtieth annual meeting of the Association, at Tulsa, March 27, 1945.

² Chairman, medal award committee.

WALLACE EVERETTE PRATT
FIRST SIDNEY POWERS MEMORIAL MEDALIST
AN APPRECIATION¹

E. DEGOLYER²
Dallas, Texas

Wallace Everette Pratt was born in Phillipsburg, Kansas, March 15, 1885, the son of William Henry and Olive Bell Bostetter Pratt.

Phillipsburg, founded only a short 13 years previously, is the county seat of Phillips County, one of the northernmost tier of counties in the state, and lies just west of the center of the Kansas-Nebraska line. It sits on the extreme eastern edge of the High Plains and is in the short-grass country. It was of the short-grass country that Charles Goodnight, the old Texas cowman, said, "It produces better cattle; why shouldn't it produce better men?"

This was the west. The Union Pacific to the north and the Santa Fe to the south had been built less than 20 years before. A great wave of land-hungry immigrants had swept over western Kansas; the initiation of the last and greatest land boom of our whole history as a nation. It was the west of the buffalo hunters, of the sod house, and of free range. It was the west of Wild Bill Hickok and Abilene, of Bat Masterson and Dodge City, of the Lincoln County war and Billy the Kid. It was the west of the Indian wars, of the Massacre of the Little Big Horn, of the Dull Knife Raid, and of the Battle of Wounded Knee.

In this west, Wallace E. Pratt spent his boyhood and had his schooling. He graduated from the Phillipsburg High School in 1901. If the horizon of the great plains was wide—almost limitless—it was also featureless and the boy Pratt found in it but little inspiration. In 1903, he set out for the State University at Lawrence. With that touch of the philosopher in the boy which has always marked the man, his first objective was a satisfactory way of life. In those stern days, however, so vague though fundamental a search soon focused itself upon the more concrete one of finding not a way of life, but a way of making a living.

Wallace Pratt graduated from the University of Kansas, A.B., 1907, B.S., 1908, and A.M., 1909. He received the degree of Engineer of Mines in 1914. As was common with many students of his generation, he "worked his way" through the University, first as night clerk at the old Eldridge House, and later as assistant in various capacities to the head of the department of geology. During 1908 and 1909, he was an assistant on the University Geological Survey of Kansas. In 1909, after 6 years at the University, he left to become a geologist in the Division of Mines, Bureau of Science, Philippine Islands.

While in the University, Pratt, to use his own words, "had remained an

¹ Introduction of the medalist.

² DeGolyer & MacNaughton.

obscure student in Haworth's classes a long time" before, quite by accident, he had come to the favorable attention of that able geologist. It is the friendly counsel and interest of Erasmus Haworth through these several years that Pratt regards as the dominant factor in his student life.

One can not take up a consideration of the subject in which we are chiefly interested—the professional career of Mr. Pratt—without making what amounts to a footnote regarding one of his outstanding characteristics. He is a modest man. One of his long-time business associates describes him as "modest to a fault. Modest almost to the point of self-effacement." His own viewpoint confirms this friendly judgment to a large degree. In responding to my high-pressure—not to say blackmail—tactics in questioning him as to what he attributes his success and in order to escape the reply which he apparently desired to make that he had "simply been lucky," he concluded that it "does appear to me to be largely fortuitous." Further emphasis of his retiring attitude is yielded by the fact that in these replies he always bracketed the word success with quotation marks.

It will come as no surprise to you, therefore, to know that he regards the early part of his Philippine career as being somewhat that of a failure. "I failed to impress anybody," says he and "After a year the chief of the division had written me off, the senior geologist was disgusted with me, and everyone ranked me close to the foot of the list." Luck intervened, according to the modest subject of our essay. On January 29, 1911, Taal Volcano, 70 miles south of Manila, erupted violently and shocked the world into a knowledge of its existence. The chief of the division was on vacation. His immediate chief was in China. Pratt was in Manila with no particular assignment, knew Taal very well, and on his own initiative undertook to find out what had happened. He got to the crater itself before any other competent observer and was perhaps the first to realize that thousands of people had been killed. In his own words, "The eruption made me. It took a cataclysm to do it." A year later he was promoted to be chief of the Division of Mines, a position in which he remained until 1916, when he terminated his employment in the Philippines and returned to the United States.

Upon his return to his native country, he became a division geologist for The Texas Company, whose chief geologist at that time was Elmer Grant Woodruff.

As we begin an appraisal of his career as a petroleum geologist at this point, it may be well to digress for a moment in order to compare and contrast those two lifelong friends, Sidney Powers, in whose memory was established the award which is about to be made, and Wallace E. Pratt, who is about to be its first recipient. Courage, sincerity, and simplicity are marked virtues of both men. As I have said in a memorial to him, Powers loved the science of geology for itself. His standards were strictly scientific and he was conscientiously but only mildly interested in the application of the science to economic ends. Powers was a

great geologist with wide interests in the whole of that field of science. Pratt's interest is "in the broad engineering enterprise which applies art and science to the winning of useful raw materials from the earth's crust." He recognizes the limitations of the science in the art of prospecting, an admission which Powers would have been loath to make, and is keenly interested in the application of the science to the art, a matter which would have been of secondary interest to Powers. One can not accept Pratt's underrating of his own ability as a geologist as those of "a very slender reed." By training and inclination, one was the scientist, the other the engineer.

During his student days Pratt assisted in the preparation of that now almost forgotten classic of early petroleum geology, Volume IX of the Kansas University Geological Survey on "Oil and Gas Resources of Kansas." In truth, the entire production of the state at that time amounted to only a few thousand barrels of oil daily, the resources did not appear to be impressive, and broader experience has since demonstrated that some of the ideas then held regarding both the geology of the state and the nature of oil occurrence are not valid. "If oil and gas are escaping at the surface," they wrote, "it is a sure indication that they do not exist in the depths below . . . in very large quantities." The "Mississippi Lime," or was it the Oswego?, was regarded by both geologists and so-called practical men of the industry as the absolute lower limit of possible oil production and most drilling contracts provided for specific depth or abandonment when the "lime" was reached. The entire state was believed to be a simple westward-dipping monocline of an extremely thick series of sedimentary rocks. There was no hint of the Barton arch or the buried Nemaha ridge. Indeed, but a few years later when a wildcat well discovered the "Ridge" by finding granite at a little more than a thousand feet in depth, the whole State Survey group was indignant in its denial of the possibility of such occurrence and "Daddy" Haworth, nailing his colors to the mast, went down fighting such heresy.

From the very beginning of his professional career, clear sightedness and a scrupulous honesty have marked Pratt's attitude toward the science of geology. In a paper on North-Central Texas read at the fourth annual meeting of this Association in 1919 and at a time when many oil men were still inclined to look askance at the recent invasion of their business by geologists, he stated his considered viewpoint as follows.

Petrolia, Electra and Burkburnett were discovered by accident, and even in their development geology has not been prominent because of lack of surface control. Moran and Strawn likewise came into production without geological assistance, although the geologists followed and mapped the small structure with which production at each place was associated. . . . The problems of geology in North Central Texas today are research problems, and a geological department in the petroleum industry today should be on the same basis as are research departments in other large progressive industries.

More than a quarter-century later, if I may quote from an unpublished letter, he succinctly summarizes his mature viewpoint as follows.

My knowledge of geology, however, is sufficient to permit me to realize its limitations as a guide to exploration. In its turn, it also is a very slender reed to lean upon in the search for petroleum. It is my observation that petroleum geologists too commonly fall into error by reliance on inadequate geological evidence. Positive action on insufficient evidence is often justifiable in our profession but to refrain from venturing because the evidence is not wholly favorable is often near tragedy for the geologist.

At the close of the year 1917 Pratt had completed his contract with The Texas Company, the last assignment of which had been that of division geologist for North Texas, and had set up a royalty-buying enterprise for himself. Early in 1918, upon the recommendation of Frank Cullinan, then retiring as vice-president in charge of production for The Texas Company, Pratt was engaged by the Humble Oil and Refining Company as a geologist.

The company was young and vigorous. It had been organized during the early and middle months of 1917 by a combination of independents, all of whom had been successful in their various enterprises in Texas and Oklahoma. The first officers elected were Ross S. Sterling (afterward Governor of Texas) as president and W. S. Farish, R. L. Blaffer, H. C. Wiess, and W. W. Fondren as vice-presidents. It was this group that Cullinan could also recommend to Pratt at so early a date as "the best people in Texas." Since he was to be the company's sole geologist as they then planned it, Humble gave him the title of chief geologist.

Ranger had just started its meteoric and subsequently disappointing career and Pratt was hired by Humble because of his intimate knowledge of that district. In April of 1920, largely on the strength of Humble's holdings in the Ranger district, a half interest in the company was acquired by Standard Oil Company (New Jersey) who, after an appraisal by Arthur J. Corwin, put in 17 million dollars against the company's properties. Ranger collapsed. Pratt's description of this critical period and of his own position with the company at this time is, I am afraid, too colored by his excessive modesty. He had helped Mr. Farish negotiate the sale to Standard.

But from that time forward my position with Humble dwindled rapidly and soon all but reached the vanishing point. Ranger flopped. The 17 million dollars, what with pipe lines, refinery, and leases, all built around Ranger, had been squandered. The future looked black and my stock was at low ebb.

Actually, it was the early thirties before the position of Humble as an oil producer became satisfactory. The early growth of the company was supported by the earnings of the Humble Pipe Line Company which increased steadily from almost 5 million dollars in 1922 to almost 10 million dollars annually in 1925 and 1926, reached a high of 27 million dollars in 1929, and again sank back to a 4 to

5 million dollar rate in the early thirties. Production showed very satisfactory not to say magnificent profits during some years but was as likely as not to show a substantial loss during the following year. It is worthy of note that this condition was not confined to Humble but was common to many companies in the period of wide range of price fluctuation and before crude prices were stabilized by the effective establishment of proration as a control in the early thirties.

Another of the marked abilities of Mr. Pratt is that of being able to change his mind rapidly. In 1921, Colonel Humphreys and Julius Fohs took up the exploration of the Mexia anticline. Pratt denounced this enterprise to his associates. He said there was no Woodbine sand at Mexia—it had pinched out. Moreover, it carried fresh water at Corsicana, only a short distance to the north, where it had been tested. He was confirmed in his skepticism when he learned later from a little plane-table work in the field that there was really no anticline at Mexia—only a strike-fault of some 300 feet throw, a fact which became more clearly revealed as continued drilling added subsurface data to the plane-table picture. Exploration of Mexia, however, resulted in the discovery of a prolific oil field and Mr. Pratt changed his mind. He says,

Then, suddenly at the end of a dreary week in the field where my associate Dwight Edson and I had been utterly distracted by conflicting and all too obscure wisps of evidence, we had a brainstorm. The fault plane was not vertical as we had assumed it to be but, on the contrary, its hade was so flat that it cut the Woodbine sand, 3,200 feet below the surface, along a line nearly three-quarters of a mile west of its trace in the Midway Limestone at the surface! Production was bound to extend far to the west of generally accepted western limit. We went into action instantaneously; the next day was a Sunday but Mr. Farish came up from Houston at our request and we leased everything that was loose west of the surface fault out to the line we drew. A few days later Tump Bass' historic well one-half mile west of the fault line got the Woodbine extremely high and the cat was out of the bag, although for some weeks almost no one recognized the real significance of the Bass well even in the Mexia Field, to say nothing of the area along the extensive fault zone that stretched northeast from Mexia to Powell.

As was to occur many times subsequently, Pratt backed his play.

"We spent all that the Humble could reasonably hazard. I pled for more."

The net result of this early understanding of the true condition of oil occurrence at Mexia was to net the Humble a little less than 10 per cent of the entire production of that spectacular field and, when the even more spectacular Powell field was discovered early in 1923, the Humble boldly applied the same rule and came out with about one-third of the production of that field.

Pratt remained chief geologist of the Humble from 1918 to 1924, when he was elected a director of the company. In 1926 he was succeeded by Eugene Holman. He had brought Holman to the company as scout and geologist in 1922. In 1922 W. S. Farish became president of the Humble, succeeding R. S. Sterling. There had always been close collaboration between Pratt and Farish and it increased with the years to such a degree that one of their close associates expresses the opinion that "no man except possibly Farish has had greater influence on the

American oil industry during the past 10 years than Wallace Pratt." Pratt became a vice-president of the company in 1930 and retained that position until 1937, when, following Farish who in 1933 had left Humble to become chairman of the board of Jersey and its president in 1937, he resigned to become a director and member of the executive committee of the Jersey company. He became a vice-president of the company in 1942. He retires shortly from these positions.

The acquisition of proved reserves to a satisfactory degree by a corporation calls for good organization and team work. These the Humble had during the period from 1928 to 1933, when it built up its domestic reserves to an amount estimated at more than double those of its nearest competitor. We would have to be more modest than Wallace Pratt himself if we did not give him the greatest credit for this achievement. The technical work was done by the organization which he had builded and he was its spark plug and ultimate director. The building of this supreme reserve position is an achievement which merits some attempt at analysis and, although I must apologize in advance for the inadequacy of my information as well as inaccuracies to which it may be subject, I will attempt to express a view.

Humble, even under Pratt's skillful direction, was not notably successful as an oil finder until after advent of geophysical prospecting. It was supremely skillful as a buyer. Mexia and Powell were the foundation stones upon which the company's greatest success as a producer were based. They were discovered by others, however, and the manner of the company's participation in their success has already been described. Humble brought in the first commercial producer at Racoon Bend on February 3, 1928, after core-drilling with shallow gas wells in 1927. A little less than two months later, March 26, 1928, it brought in the discovery well at Sugarland. This prospect had been found with a torsion balance by H. C. Cockburn and Humble, having got a fast refraction shot across the area, bought the prospect from him.

December 4, 1928, the discovery well of the great Oklahoma City pool was completed and it was the beginning of a period of over-production and great distress in the oil industry; a distress which was emphasized by the coming of the years of the national depression which began in October, 1929.

The great Van field, in which the company was substantially interested, was discovered October 14, 1929. The impact of Oklahoma City on the industry had already begun to be felt and it is notable that within fifteen days of this discovery a unit plant for the field's operation had been perfected. Finally, in October, 1930, Dad Joiner brought in the discovery well of the mammoth East Texas field.

One might say that the period beginning roughly with the discovery of the Oklahoma City field at the end of 1928 and ending with the Code for Fair Practice in the Petroleum Industry promulgated under the National Industrial Recovery Act in the early autumn of 1933 was a period of uttermost demoralization in the petroleum industry. It was a period of over-production, low prices,

attempts at voluntary proration, hot oil, military law in the Oklahoma City and East Texas fields, court action to establish proration by State regulation, attempted federal regulation, and of many other evils consequent upon these events. The period ended when it did because the various State conservation laws had finally been established judicially and, with the backing of the Connally Hot Oil Act, State regulation had finally become reasonably effective. The price of crude oil reached a living stage speculatively in anticipation of benefits which were to accrue from the administration of the Petroleum Code but which, during the short life of that ill-fated instrument, were never realized.

It was during this dismal period that Humble, through prospecting and purchases but largely through skillful purchases, achieved its paramount reserve position. On December 28, 1930, E. W. Bateman completed No. 1 Crim with an initial production of approximately 10,000 barrels a day, proving an important extension of the newly discovered East Texas field, and a few days later Humble bought his well and approximately 1,400 acres of leasehold, paying, according to press reports, one and one-half million dollars in cash and some six hundred-thousand dollars out of oil. In 1932, Humble bought the Strake properties at Conroe, according to press reports, for four million dollars cash and three and one-half million dollars out of one-quarter of the oil. About the same time they also purchased the Cullen and West half-interest in the Thompson field at a price reputed to be three million dollars cash and seventeen million dollars out of one-quarter of the oil. They also purchased substantial leasehold in the Hastings field, discovered by Stanolind.

On the discovery side, they were partners in the bringing-in of the Tom O'Connor field; found the Anahuac and Webster fields; and somewhat later than the period under immediate review, although they did not drill the discovery well, found and owned most of the acreage in the Hawkins field.

Approximately four-fifths of the company's reserves are in the eight fields mentioned. Its reserves are approximately equal in the four fields discovered by the company with its reserves in the four fields discovered by others.

Those of us who have followed trading in producing oil properties in Humble territory will realize that the cash expenditures for the properties purchased were not great. At least two other companies have made greater expenditures for production; one of them has made much greater expenditures. One must give due weight to the demoralized state of the market during the period in which the purchases were made but even after making such allowance, one must conclude that the purchases were skillfully made. In my opinion, almost immediate recognition of values is basically important in the best of the trades.

One of Pratt's greatest achievements was the leasing for his company of that unknown and mysterious kingdom of South Texas into which ultimately extend all important oil fields of the area which are discovered outside its boundaries. I refer to the King Ranch. The story of the actual making of the lease; the efforts to reduce the size of the risk by taking partners; the interminable waiting until

the lessor could devise a satisfactory form of instrument; these make a long story and, although it is interesting, one not particularly germane to our present purpose. We are interested chiefly in the courage, pertinacity, and broad vision of Mr. Pratt in bringing this dream to reality and for the best account of its accomplishment, I refer again to his own words.

This job took fifteen years. In the beginning its justification demanded a broader view of geology and oil-finding than most petroleum geologists possessed. The territory was not generally looked upon with favor. In the late 1920's I tried to persuade three other large companies to join Humble in a joint King Ranch lease. I sought the views of a prominent consulting geologist, hoping to find in them support which I might use to advantage. But this consultant also condemned the region as one which exploration had already shown to possess little promise for petroleum. The trouble, he felt, was that no petroleum could have originated in rocks so little disturbed subsequent to deposition, as those occupying the Rio Grande embayment.

As I have noted elsewhere, one of Wallace Pratt's marked abilities is that of being able to make a prompt decision. I hope that, in stressing his excessive modesty, I have not overshadowed the streak of iron in his soul and his firmness in his convictions. One of his former assistants notes that "when I first met Wallace, his square jaw impressed me most." I can confess to having seen, on several occasions, the skin whiten as it tautened over that same square and firmly set jaw. Fortunately, it was provoked by me on only one occasion and having seen it before when provoked by another, I realized the no-compromise attitude which it betokened and retired as gracefully as I might under such circumstances.

Strangely enough and as has been mentioned also, his ability to change his mind quickly is quite as marked a characteristic. When the seismograph was introduced into the Gulf Coast, Pratt was skeptical and told his associates that geophysics' chances of success were all but nil, but, with its first successes, he "turned a complete right-about and started desperately to build up a seismic enterprise" for his own company. I seem to remember that in the earliest days of the reflection seismograph, he told me that there were no such things as reflections and that even if there were, they could not be observed!

There is a story that when Cullen offered Humble a half-interest in the early gravimeter prospect which was afterward developed into the magnificent Tom O'Connor field, Pratt declined it but, before Cullen could get to the elevator, Pratt had caught up with him. He had changed his mind. Fast work for more than a hundred million barrels of oil!

In my opinion, Wallace E. Pratt is a good scientist and an able engineer, possessed of excellent business acumen, the whole combined and mellowed into the philosopher which he really is. None of us who have competed with the Humble in oil finding in Texas during the last quarter-century, even on a modest scale, but have had to come to some conclusion with regard to the strength and weakness of Mr. Pratt. What his weaknesses may be, I do not know. I have never been able to sell him any leases. He turned back the Texas end of the Rodessa

field to its original owners at cost and he has turned down many deals which, had they been accepted, would have profited his company substantially. The business of an oil finder, however, is to secure enough good properties for himself or his principals, rather than to make every decision correctly, an effective margin of success over failure, and in this endeavor Mr. Pratt has been eminently successful. Much of his success has been due to the broad stage upon which he worked, the great resources behind him, and the unwavering and unremitting confidence and support which he has been able to inspire in his executives and directors. For many years it has seemed to me that, in addition to the virtues of technical competence and good judgment which are doubtless possessed to somewhat as great a degree by many men similarly engaged, Mr. Pratt's genius has been in his courage and his ability to make up his mind quickly, even changing it completely if necessary, and the even rarer ability to look at any situation at any time as if he had never before seen it. I want to make this last point clear. To my mind, he is like a master who plays many boards of chess simultaneously, looking at each situation with cold scientific precision and without regard to its history. If a wildcatter had offered a block and well at cost at five o'clock one evening and if the well had come in as an excellent discovery during the night, most of us would not be able to deal at nine o'clock the next morning on the basis of real values. We could not get over regretting the opportunity we had missed by not buying cheaply the night before and the worst of us would have humored our consciences by the hoping that the well would go to water quickly and thus prove our judgment. Most of us would have done these things. Mr. Pratt, in my opinion, is the rare exception who would have proceeded at nine A.M. in view of the changed situation as it then stood and his judgment would not have been delayed or warped because of previous happenings.

Mr. Pratt is a member of many technical and scientific societies. He became a member of this Association in 1918 and was elected its fourth president at the Dallas meeting in 1920. He is a member of the American Petroleum Institute and was a director, 1928-1934. He is a member of the American Institute of Mining and Metallurgical Engineers, of which he is at present a director. He is also a fellow of the American Association for the Advancement of Science, of the Geological Society of America, and of the American Geographical Society and a member of Sigma Xi, of the Society of Economic Geologists, and of the Mining and Metallurgical Society. He is an honorary member of the Society of Exploration Geophysicists.

I am not acquainted intimately enough with Pratt's activities as a director and executive of the Jersey during the seven or eight years that he has spent in those posts to be able to make more than the most superficial comments. This can be done at some future date by some of those who have been closely associated with him.

Throughout his whole career as an executive and administrator he has demonstrated a superb ability to select and train men and, through the exercise of his

genius in this phase of his activity, he has multiplied, made effective, and improved upon his own material and technical skills manyfold. In so doing he has raised the profession of petroleum geology to an eminence and a dignity which it would not otherwise have attained. More than any other man, perhaps, he has brought to the general public an awareness and appreciation of the importance of the science of geology to the arts of prospecting for and producing oil. In his own words, "The winning of oil is a geologic enterprise."

As a business associate, he has always commanded the respect and support of his co-directors. Gently persuasive in argument, friendly and understanding as a man, he has been able to avoid difficulties by anticipating trouble and by reconciling conflicting interests and by coordinating varying viewpoints.

In closing, I join enthusiastically in the warm-hearted appraisal of Wallace E. Pratt by another member of this Association, his erstwhile assistant and present chief, Eugene Holman:

He believes in the brotherhood of man. He has a host of friends in all countries of the world, regardless of creed or color. He is beloved by all.

BIBLIOGRAPHY, WALLACE E. PRATT*

- Pratt, Wallace E. and Adams, Geo. I., "Miscellaneous Non-Metallic Materials," *Min. Resources, Philippine Islands, 1909* (1910), p. 53.
 —, "Philippine Pottery," *Philippine Journal of Science*, Vol. 5, Sec. A (1910), p. 143.
 Pratt, Wallace E. and Dalburg, "Report on the United States Army Coal Mine at Lignan, Batan Island," *private report* (1910).
 Pratt, Wallace E., "Notes on the Mineral Resources of Catanduanes Island," *Min. Resources, Philippine Islands, 1910* (1911), p. 28.
 Pratt, Wallace E. and Adams, Geo. I., "Geological Reconnaissance of Southeastern Luzon," *Philippine Journal of Science*, Vol. 6, Sec. A (1911), p. 35.
 —, "The Nalasvetan, Camarines, Gold District," *Min. Resources, Philippine Islands, 1910* (1911), p. 53.
 —, "Philippine Production of Non-Metals in 1910," *Min. Resources, Philippine Islands, 1910* (1911), p. 61.
 —, "The Eruption of Taal Volcano," *Philippine Journal of Science*, Vol. 6, Sec. A (1911), p. 63.
 —, "A Note on Briquetting Philippine Coals," *Min. Resources, Philippine Islands, 1910* (1911), p. 79.
 —, "The Baguio Mineral District in 1911," *Min. Resources, Philippine Islands, 1911* (1912), p. 22.
 —, "Philippine Production of Non-Metals in 1911," *Min. Resources, Philippine Islands, 1911* (1912), p. 48.
 —, "Portland Cement Manufacture in the Philippines," *Min. Resources, Philippine Islands, 1911* (1912), p. 82.
 —, "Recommendations as to Artesian Well Drilling in the Island of Panay," *private report* (1912).
 —, "Philippine Production of Non-Metals in 1912," *Min. Resources, Philippine Islands, 1912* (1913), p. 41.
 Pratt, Wallace E. and Smith, Warren D., "Petroleum on Bondoc Peninsula, Tayabas," *Min. Resources, Philippine Islands, 1912* (1913), p. 49.
 —, "The Geology and Petroleum Resources of the Southern Part of Bondoc Peninsula, Tayabas Province, Philippines," *Philippine Journal of Science*, Vol. 8, Sec. A (1913), pp. 301-76.
 Pratt, Wallace E., "Petroleum in Tayabas Province, Philippines," *Proc. International Geological Congress* (Toronto, 1913).
 —, "Geology of a Proposed Site for a Reservoir at Bayambayanan, Rizal, P. I.," *private report* (1913).

* NOTE.—The only private reports included are those of a semi-official nature. Mr. Pratt contributed much material to David White for his estimate of petroleum reserves made during 1922 and a very substantial amount of material to the various oil articles of Isaac F. Marcasson published in the *Saturday Evening Post*.

- , "Geology and Exploration of the Uling Coal Field, Uling, Cebu," *private report* (1913).
- Pratt, Wallace E. and Smith, Warren D., "The Geology of the Petroleum Claims of Uling," *private report* (1913).
- Pratt, Wallace E., "Philippine Coal Mining in 1913," *Min. Resources, Philippine Islands*, 1913 (1914).
- , "The Angat, Bulacan, Iron Ore Resources," *Min. Resources, Philippine Islands*, 1913 (1914).
- , "Petroleum in the Island of Cebu," *Min. Resources, Philippine Islands*, 1913 (1914).
- , "Geology and Field Relations of Portland Cement Raw Materials at Naga, Cebu," *Philippine Jour. Sci.*, Vol. 9, Sec. A (1914), p. 151.
- Dalburg, F. A. and Pratt, Wallace E., "The Iron Ores of Bulacan Province, P. I.," *Philippine Journal of Science*, Vol. 9, no. 3 (June, 1914), p. 201.
- Pratt, Wallace E., "Mineral Resources of the Philippine Islands in 1914" (1915).
- , "Underground Waters of the Philippines from a Geological Standpoint," *Philippine Jour. Sci.*, Vol. 10 (1915).
- , "Geological Reconnaissance in Caramoan Peninsula, P. I.," *Philippine Jour. Sci.*, Vol. 10 (1915).
- , "Iron Ore on Calambayanga Island, Mambulao, Camarines Province, P. I.," *Philippine Jour. Sci.*, Vol. 10 (1915), Sec. A, p. 323.
- Pratt, Wallace E. and Lednicky, Victor E., "Iron Ore in Surigao Province, P. I.," *Philippine Jour. Sci.*, Vol. 10 (1915), Sec. A, p. 335.
- Pratt, Wallace E., "The Persistence of Philippine Coal Beds," *Philippine Jour. Sci.*, Vol. 10 (1915).
- , "Petroleum and Residual Bitumens in Leyte," *Philippine Jour. Sci.*, Vol. 10 (1915), A, pp. 241-78.
- , "The Occurrence of Petroleum in the Province of Cebu," *Philippine Jour. Sci.*, Vol. 10 (1915), A, pp. 281-86.
- , "An Unusual Form of Volcanic Ejecta," *Jour. Geology*, Vol. 14 (1916), p. 450.
- , "Coal Mining in the Philippines," *Coal Age*, Vol. 9 (1916), p. 491.
- , "The Lakes of the Philippine Islands," *Philippine Jour. Sci.*, Vol. 9 (1916), p. 9, 223.
- , (Discussion of) Kemp, James F., "The Geology of Iron Ore Deposits," *Amer. Inst. Min. and Metal Eng., Trans.*, Vol. 53 (1916), pp. 38-39.
- , "The Iron Ores of the Philippine Islands," *Amer. Inst. Min. and Metal Eng., Trans.*, Vol. 53 (1916), pp. 90-105, 2 figs.
- , "Occurrence of Petroleum in Philippines," *Econ. Geol.*, Vol. 11 (1916), pp. 246-65, 1 fig.
- , (Discussion of) Powers, Sidney, "Age of the Oil in Southern Oklahoma Fields," *Amer. Inst. Min. and Metal Eng., Trans.*, Vol. 59 (1918), pp. 576-77.
- , (Discussion of) Hager, Dorsey, "Geology of Oil Fields of North Central Texas," *American Inst. Min. and Metal Eng., Trans.*, Vol. 61 (1919), pp. 530-31.
- , "Geologic Structure and Producing Areas in North Texas Petroleum Fields," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 3 (1919), pp. 44-70.
- , "Geologic Structure and Producing Areas in North Central Texas Petroleum Fields," *Oil Weekly*, No. 129 (March 29, 1919), p. 35; No. 130 (April 5, 1919), p. 40; No. 131 (April 12, 1919), p. 40; 2 figs.
- , (Discussion of) Smith, Warren DuPre, "Petroleum in the Philippines," *Amer. Inst. Min. and Metal Eng., Trans.*, Vol. 65 (1921), pp. 54-56.
- , "The Present Excitement at Fort Stockton, Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 5 (1921), pp. 88-89.
- , (Discussion of) Hackford, J. E., "Nature of Coal," *Amer. Inst. Min. and Metal Eng., Trans.*, Vol. 65 (1921), p. 223.
- , (Discussion of) Hicks, Clarence J., "Industrial Representation in the Standard Oil Co. (N. J.)," *Amer. Inst. Min. and Metal Eng., Trans.*, Vol. 65 (1921), p. 240.
- , (Discussion of) Washburne, Chester, "Oil-Field Brines," *Amer. Inst. Min. and Metal Eng., Trans.*, Vol. 65 (1921), p. 289.
- , "The Recent Discovery at El Dorado, Arkansas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 5 (1921), pp. 90-91.
- , "A Note on Supposed Evidence of the Volcanic Origin of Gulf Coast Salt Domes," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 5 (1921), pp. 91-94.
- , "Possible Petroleum Resources of Philippine Islands," *Mining and Metallurgy*, Vol. 3 (July, 1922), no. 187, p. 42.
- , "A New Gulf Coast Salt Dome," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 6 (1922), pp. 252-54.
- , "Possible Petroleum Reserves of Philippine Islands," *Amer. Inst. Min. and Metal Eng., Trans.*, Vol. 48 (1923), pp. 1091-96, 2 figs.
- , "Oil at Luling, Caldwell County, Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 7 (1923), pp. 182-83.
- Pratt, Wallace E. and Lahee, F. H., "Faulting and Petroleum Accumulation at Mexia, Texas,"

- Bull. Amer. Assoc. Petrol. Geol.*, Vol. 7 (1923), pp. 226-36; *Oil Engineering and Finance*, Vol. 4, no. 82 (Aug. 4, 1923), pp. 119-22, 4 figs.
- Pratt, Wallace E., "Oil and Gas in the Texas Panhandle," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 7 (1923), pp. 237-49.
- , "Two New Salt Domes in Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 10 (1926), pp. 1171-72.
- Pratt, Wallace E., and Johnson, Douglas W., "Recent Local Subsidence of the Gulf Coast of Texas (abstract)," *Geol. Soc. America, Bull.*, Vol. 37, no. 1 (March 30, 1926), p. 169; *Pan-Am. Geologist*, Vol. 45, no. 2 (March, 1926), pp. 166-167.
- Pratt, Wallace E. and Sellards, E. H., "Depression of Goose Creek Oil Field, Texas (abstract)," *Pan-Am. Geologist*, Vol. 45, no. 3 (April, 1926), p. 254.
- Pratt, Wallace E., "An Earthquake in the Panhandle of Texas," *Seismological Soc. America, Bull.*, Vol. 16, no. 2 (June, 1926), pp. 146-49, 1 pl.
- Pratt, Wallace E., and Johnson, Douglas W., "Local Subsidence of the Goose Creek Oil Field," *Jour. Geology*, Vol. 34, no. 7 (Oct.-Nov., 1926), pp. 577-90, 6 figs.
- Pratt, Wallace E., "Some Questions on the Cause of the Subsidence of the Surface in the Goose Creek Field, Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 11 (1927), pp. 887-89.
- , (Discussion on) "Subsidence and Earth Movements Caused by Oil Extraction or by Drilling Oil and Gas Wells," *Amer. Inst. Min. and Metal. Eng., Trans.*, Vol. 75 (1927), p. 740.
- , "A Wildcatter's Dream," *The Lamp* (April, 1927).
- , "Oil in the Making," *The Lamp* (August, 1927).
- , "Diatoms Seen as Probable Source of Petroleum," *Oil Weekly*, Vol. 47, no. 3 (Oct. 7, 1927), pp. 33-34, 44, 3 figs. (Spanish) *Bol. Petroleo*, Vol. 25, no. 1 (Jan., 1928), pp. 19-33.
- , "Sermons in Stone. The Religion of a Geologist," *The Congregationalist* (Boston, 1928).
- , "Oil-Minded Albion," *Min. and Metallurgy*, Vol. 9 (Nov., 1928), no. 263, pp. 502-03.
- , "Sermons in Stones," 15-page pamphlet, Houston, Texas, n.d. (1928). (A sermon delivered in the First Congregational Church at Houston, Texas, February 26, 1928.)
- , "Industry Must Drill 20,000 Wells Yearly," *Oil and Gas Jour.*, Vol. 30, no. 9 (July 16, 1931), pp. 19, 102-03.
- , (Discussion of) Oliver, Earl, "Stabilizing Influences for the Petroleum Industry," *Amer. Inst. Min. and Metal. Eng., Trans.*, Vol. 98 (1932), p. 35.
- , (Discussion of) Pogue, Joseph E., "Economics of Proration," *Amer. Inst. Min. and Metal. Eng., Trans.*, Vol. 98 (1932), pp. 77-80.
- , "Hydrogenation and the Origin of Oil," *Amer. Assoc. Petrol. Geol.*, "Problems of Petroleum Geology" (Sidney Powers memorial volume), (1934), pp. 235-45: (abstracts) *Pan-Am. Geologist*, Vol. 62, no. 2 (Sept., 1934), pp. 146-47; 16th *Internat. Geol. Cong. 1933 Rept.*, Vol. 2 (1936), pp. 1009-10.
- , "Oil Production Analysis of Its Development and Stabilization," *Oil and Gas Jour.*, Vol. 33, no. 50 (May 2, 1935), pp. 17-18.
- , "Petroleum: Its Origin, Production, and Future," *Lubricator* (Hum. O. & R. Co.), October 3, 1935.
- , (Review of) "Petroleum Technology, 1935. The Institution of Petroleum Technologists, Special Publication," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, no. 11 (Nov., 1936), pp. 1501-04.
- , "Prospects for Petroleum," *The Wharton Review of Finance and Commerce* (U. of Penn.), Vol. 9, no. 6 (March, 1936).
- , (Discussion of) Pogue, Joseph E., "The Role of Drilling in the Functioning of Proration," *Amer. Inst. Min. and Metal. Eng., Trans.*, Vol. 118 (1936), pp. 290-91.
- Pratt, Wallace E. (pen name Philip Morris), "Oil: the Arch Fugitive," *Sunday Item Tribune* (Houston, Texas, March 14, 1937).
- Pratt, Wallace E., "Discovery Rates in Oil Finding," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 21, no. 6 (June, 1937), pp. 697-705.
- , (Review of) "Origin and Production of Crude Petroleum," *The Science of Petroleum*. A comprehensive treatise of the principles and practice of the production, refining, transport, and distribution of mineral oil. A. E. Dunstan, A. W. Nash, B. T. Brooks, and Sir Henry Tizard, Editors. Vol. 1, part 1, Sections 1-17, pp. 1-836 (Oxford University Press, New York, 1938). *Industrial and Engineering Chemistry*, New edition, Vol. 16 (1938), pp. 34C-41.
- , "Thirty Year Oil Fields," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 22, no. 12 (December, 1938), pp. 1608-99.
- Pratt, Wallace E. and Weeks, L. J., "History of Oil Exploration with Particular Reference to Finding Rates," *Amer. Petroleum Inst., Finding and Producing Oil* (1939), pp. 7-18, 6 figs., 7 tables.
- Pratt, Wallace E., "The Basis of Proration in Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 23, no. 9 (Sept., 1939), pp. 1314-19.
- , "Donald Clinton Barton, An Appreciation," *Mining and Metallurgy*, Vol. 20, no. 395 (Nov., 1939), p. 529, 1 fig., portrait.

- , "Donald Clinton Barton (1889-1939)," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 23, no. 12 (Dec., 1939), pp. 1888-96, 1 fig., portrait.
- , "Memorial to Donald Clinton Barton (1889-1939)," *Geol. Soc. America, Proc.*, 1939 (June, 1940), pp. 153-66, 1 pl., portrait.
- , "Geology in the Petroleum Industry," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 24, no. 7 (July, 1940), pp. 1209-13.
- , "The Shifting Crude Stream," *The Lamp* (October, 1940).
- , (Review of) "Elements of the Petroleum Industry, Everette Lee DeGolyer, editor," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 25, no. 5 (May, 1941), pp. 904-06.
- , "Oil in the Earth," 105 pp., University of Kansas Press, Lawrence, Kansas, 1942: Second edition, 110 pp., University of Kansas Press, Lawrence, Kansas, 1943 (Lectures delivered before students of Department of Geology, University of Kansas, March 17-19, 1941.)
- , "Oil Discovery Rate Three Years Hence Depends on Price of Crude Now," *Mining and Metallurgy*, Vol. 22, no. 415 (July, 1941), pp. 349-51.
- , "Oil Is Where You Find It," *Science Digest* (November, 1942). Condensed from "Oil in the Earth."
- , "The Mackenzie River—Future Highway for the United States," *Travel*, Vol. 80, no. 1 (November, 1942).
- , "Good Geologists Make Good Neighbors," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 26, no. 7 (July, 1942), pp. 1207-13.
- , (Review of) "Field Geology," by Frederic H. Lahee, *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 26, no. 9 (September, 1942), pp. 1537-38.
- , "William McCormick Reid (1911-1943)," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 27 (1943), pp. 1031-32, 1 fig., portrait.
- , "Undiscovered Reserves Equal to Those Already Found Held Probable," *Oil and Gas Jour.*, Vol. 42, no. 34 (Dec. 30, 1943), pp. 78-80.
- , "The Price of Crude Oil," *The Lamp* (October, 1943).
- , "Our Petroleum Resources," *Min. and Metal. Soc., Bull.*, no. 269 (December, 1943).
- , "Finding the World's Oil," *The Lamp* (December, 1943).
- , "Distribution of Petroleum in the Earth's Crust," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 28, no. 10 (Oct., 1944), pp. 1506-09.
- , "Oil Fields in the Arctic," *Harper's Magazine* (Jan., 1944).
- , "There Will Be Enough Oil," 10-page pamphlet, New York, 1944 (Address at annual dinner of the Oil Heat Institute of America, March 13, 1944).
- , "Petroleum in the North," *Compass of the World*, Hans W. Weigert and Vilhjalmur Stefansson, editors (1944), pp. 336-47.
- , "Our Petroleum Resources," *American Scientist* (April, 1944).
- , "Our Petroleum Resources. Plenty of Oil in the World, Our Job Is to Find It," *Mining and Metallurgy*, Vol. 25, no. 448 (April, 1944), pp. 222-24.
- , "Frederick Gardner Clapp," *Mining and Metallurgy*, Vol. 25, no. 449 (May, 1944), p. 284.
- , "We're Crying Wolf in Oil Again," *Nation's Business* (May, 1944).
- , "Are We Running Out of Oil?" *Liberty* (New York, June 3, 1944), pp. 15, 53-55.
- , "The Earth's Petroleum Resources," *Journal of Business*, Vol. 17, no. 3 (July, 1944), University of Chicago.
- , "Oil for All Our Tomorrows," *Fuel Oil News* (September 15, 1944).
- , "Clarence Herman Lieb, An Appreciation," *Mining and Metallurgy*, Vol. 26, no. 460 (April, 1945), p. 239.

GEOLOGY IS A WAY OF LIFE¹

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Frijole, Culberson County, Texas

My object in living is to unite
My avocation with my vocation
As my two eyes make one in sight.

—Robert Frost

Mr. President, Fellow Members of the American Association of Petroleum Geologists, Ladies and Gentlemen:

When scientists single out one of their fellows for an award of this kind, it is their science, itself, which they really honor. Achievement commonly springs from the sum total of the efforts of all the workers who make up the science. An award to the individual scientist testifies principally to the advance of his science at large.

In its objective content, geology along with other sciences aims at "the elimination of all personal and anthropomorphic elements." Not so our friendships: "these make the sweetness of life." The man in whose memory this award was established was a completely impersonal scientist, yet invariably his scientific inquiries led him into the warmest of friendships with his fellows.

I first knew Sidney Powers in the year 1914. En route round the world on a travelling fellowship from Harvard University, he appeared, without notice, one morning in my office in the Division of Mines in Manila. Suddenly, there he stood filling the doorway: "Powers! S. Powers!" he announced himself. He blurted out his words in a strident voice and at once proceeded to demand, in effect, that I drop whatever I had before me and take him to explore a rather inaccessible Philippine caldera, Lake Bombon, from the center of which the present crater of Taal Volcano rises. It is eloquent of the genius of the man that, stranger though he was, abrupt and brusque of manner, I did just what he stipulated; put aside my own affairs, organized a field trip and set out with him for the volcano. For a week we slept under the open sky,—tramped, debated and speculated among the rocks; then I returned him to his boat in Manila an hour before its departure, and he was gone.

I rediscovered Sidney Powers several years later along Red River in Texas after both of us had joined the ranks of the petroleum industry. He immediately reopened his spirited mental bombardment of ideas, queries, observations and hypotheses. He had already (1917) identified as of Ordovician age the deep, light-gravity oil at Healdton, Oklahoma, and had formulated his pioneer concept of the "buried hills" type of oil fields.

The succeeding years brought to me, as they did to many of you, the privilege of affectionate friendship with Sidney Powers. A short time before his death, at his instigation, we undertook a long trek by motor through the Southwest.

¹ Response by the medalist.

In the Big Bend of the Rio Grande in western Texas we threaded our way through the imposing cliffs of ancient lake beds which wall in the river valley upstream from Santa Elena Canyon. At length we climbed out of the valley and toiled on up over the axis of the rugged, colorful Chinati Mountains. We pushed ahead until, just as night overtook us, we reached the high rim of the Solitario, that incomparable geologic window, through which, during most of the following day, we peered down deep into the earth's crust, fascinated by the orderly array of volume after volume of superbly documented earth-history.

Again, we stood one evening on the crest of Hogback, the first oil field to be discovered on the communal lands of the Navajo Indians in San Juan County, New Mexico. Far to the west of us, rising to a height of 1,500 feet above the level plains, towered Shiprock, that remarkable intrusive spine which nature through the ages has sculptured into a gigantic mainsail, delicately poised before the driving wind of the desert. As we gazed at this graceful silhouette, etched by the last rays of the setting sun with a rim of jagged incandescence against the dark winter sky, we gradually became one with the Cosmos, and long before we were again aware of each other night was black around us.

Sidney Powers was of a single mind with the poet:

My object in living is to unite
My avocation with my vocation
As my two eyes make one in sight.

For this fine scientist geology was a way of life. Geology was his labor and geology was his recreation. Mentally and materially, geology gave him each day his daily bread.

In the present chaos of war, with statesmanship bankrupt and society all but prostrate, geologists may well pause to reflect that "in a changing universe scientific thought fixes the points of rest, the unmovable poles": that "it is science that gives us the assurance of a constant world."

"The universe" says Bergson "is a machine for the making of gods." Man, a "fallen god," should come then to know the earth, his own tiny sphere in the universe. As long ago as the middle of the last century, James Dwight Dana, who "first made geology a philosophic history," said: "The earth's history is the true introduction to human history." So it is that when, much later, H. G. Wells sought to write a comprehensive modern history of mankind, he saw fit to adopt as a prologue the story of geology. For man can be intelligibly portrayed only against a background of earth-history, out of which he has himself but just emerged.

We should like to convince ourselves, of course, that the evolution of living matter on the earth has as its supreme aim the present dominion of mankind. Accordingly, we are a little perplexed when we perceive that the culmination of the mammals, the class to which man himself belongs, is not man, but the whale; and that, within the whole animal kingdom, the most highly organized creature is not man, but the birds, perfectly adapted to a great variety of environments.

Reluctantly, we concede that "if in man nature tried to produce the perfect vase, all she attained was a pitcher."

Further study reveals to us, however, that evolution proceeds not along a straight line but through a parallel series of radial patterns. Nature has made ample provision "lest one good custom should corrupt the world." At length we discern the fact that evolution is not necessarily progress; that it is more accurately adjustment—the adjustment of living matter to earth conditions.

Yet the evidence also demonstrates that for 2,000 million years, the advance of evolution has taken a definite direction. This direction was identified by Dana, more than a century ago. To describe it, he invented the term "cephalization"—by which he meant the irregular process of growth and perfection of the central nervous system, beginning with the lowly cephalopoda and continuing through the intervening ages up to modern man.

It is this cephalization, the progress of the development of the brain,—man's highest attribute and the seat of his spiritual as well as his mental life—which we geologists, because of our study of earth's history, are permitted to know more intimately than most of our fellows. As the most recent phase of the long process of cephalization, we observe the amazing development of the forebrain, the seat of benevolence and the altruistic impulses, in *homo sapiens*. No geologist can remain unmoved by the exciting social and spiritual potentialities of these astonishing new tendencies in the evolution of living matter.

Is it strange, under the circumstances, that some of us think we have detected, implanted within the loins of our science, geology, the very seeds of the Christian religion? To us as we read history it is not without significance that "the great religious ones seem to have had a certainty that they were going along with the trend of the world"; that "they have had a passion for right living which they conceived of as a cosmic demand."

It requires no act of faith for the geologist to embrace the concept of the brotherhood of man. The past vicissitudes of living matter on earth proclaim it to him in a chorus of evidence so overwhelming that it drowns out any possible voice of dissent. That man should love his neighbor as himself is a tenet explicit in the same record which, deeply imprinted in the rocks of the earth's crust, reveals to the geologist the final supremacy of the principle of "mutual aid" over the doctrine of "the tooth and the claw." What the geologist finally perceives, then, when he carefully dissects the rule of the "survival of the fittest," is the emergence of the soul of man.

In his little classic, "The Origin of the Earth," T. C. Chamberlin observes that while "nothing in the whole genetic history of the earth was more distinctive than the first appearance of living organisms" and while there was in their attributes "a subtle factor not distinctly betrayed in earlier modes of evolution," yet this factor "may have been there." There are, he thinks, "intimations of something of the kind in the complexity of even inorganic combinations."

And while it is not clear that there was present in the initial stages of life any

sentient or psychologic element, Chamberlin continues, yet a dozen characteristics of primitive life "squint sharply in the direction of psychological endowments." The psychological factor "stands apart from the physiological farther even than does the physiological from the inorganic," and however occultly mentality may have crept into life processes, its advent "marked the climax of the earth's evolution."

Yet the

gradation from the seemingly insentient and merely physiological, as embodied in the lowest order of living beings, to the earliest types of sentient life, and thence on to the highest manifestations in the thinking world, is so intimate as to bind the whole into one indivisible process. If the qualities of the psychological world were potential in the factors that entered into the earlier stages of the earth's genesis, then a revision of our conception of those factors is logically required. Fundamentally, the antecedents can scarcely be less comprehensive than the consequents. If the material begets the spiritual, the material can hardly be altogether material.

And, finally, with simple eloquence, Chamberlin states his conclusion—a conclusion which some of us would seize upon as the central thesis to be woven into the fabric of a living credo for geologists:

It is our personal view that what we conveniently regard as merely material is at the same time spiritual, that what we try to reduce to the mechanistic is at the same time volitional, but whether this be so or not, the emergence of what we call the living from the inorganic, and the emergence of what we call the psychic from the physiologic, were at once the transcendent and the transcendental features of the earth's evolution.

OIL POSSIBILITIES OF SOUTH AMERICA IN THE LIGHT OF REGIONAL GEOLOGY¹

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ABSTRACT

The petroleum possibilities of a region depend on the presence of thick sections of sedimentary rock of favorable facies, preferably marine; on the conditions of sedimentation when the rocks were deposited; and on their subsequent structural history. In assessing the petroleum possibilities of South America these factors have been taken into account in so far as available data permit. The principal sedimentary basins are indicated on maps and the features of each discussed from the point of view of the petroleum geologist.

The survey indicates large areas that are potentially petroliferous, and an attempt has been made to classify them into three groups: (a) most favorable, (b) moderately favorable, and (c) possibly petroliferous but for various reasons less promising than the two preceding groups.

An unexpected result of the study was the suggestion that the eastern half of the great sub-Andean sedimentary trough may hold more accessible oil than the western half. Inaccessibility, unfavorable climate, and dense vegetation cover will retard exploration and development of the sub-Andean belt from northern Bolivia to central Colombia.

For a brief résumé of the results of the study see the "Summary" at the end of the paper.

INTRODUCTION

To describe and assess the geological features of an entire continent as they bear on the possibility of its yielding petroleum would be a difficult task even if the areal geology of the continent and the history of its geological development were fully known. The difficulties are especially great for a continent, like South America, whose geologic story has been only imperfectly deciphered.

In attempting this task at the request of a program committee of the American Association of Petroleum Geologists, the writer is fully conscious of the inadequacy of the result that he can hope to attain and of the pitfalls awaiting anyone who attempts such an appraisal with only moderate personal knowledge of the continent, and depending mainly on the published literature for his information. Nevertheless, a systematic summary, in English, of South American regional geology from the oil geologist's point of view should prove useful, and it is hoped that the suggestion of several unexpected possibilities of various parts of the continent that came to mind during the study required for the preparation of this report will prove stimulating and useful.

The plan of treatment is dictated mainly by convenience and the "lay of the land." Beginning with a belt of Late Paleozoic mountains that seems once to have stretched northwest across Argentina and northern Chile, we next consider the area at the south. Then, picking up at the north side of the ancient mountains, we follow the long sub-Andean trough,³ on the eastern border of the present

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³ Following Brazilian and German writers (de Paiva, Ahlfeld, and others), the word "sub-Andean" is used for the major structural trough immediately east of the Andes.

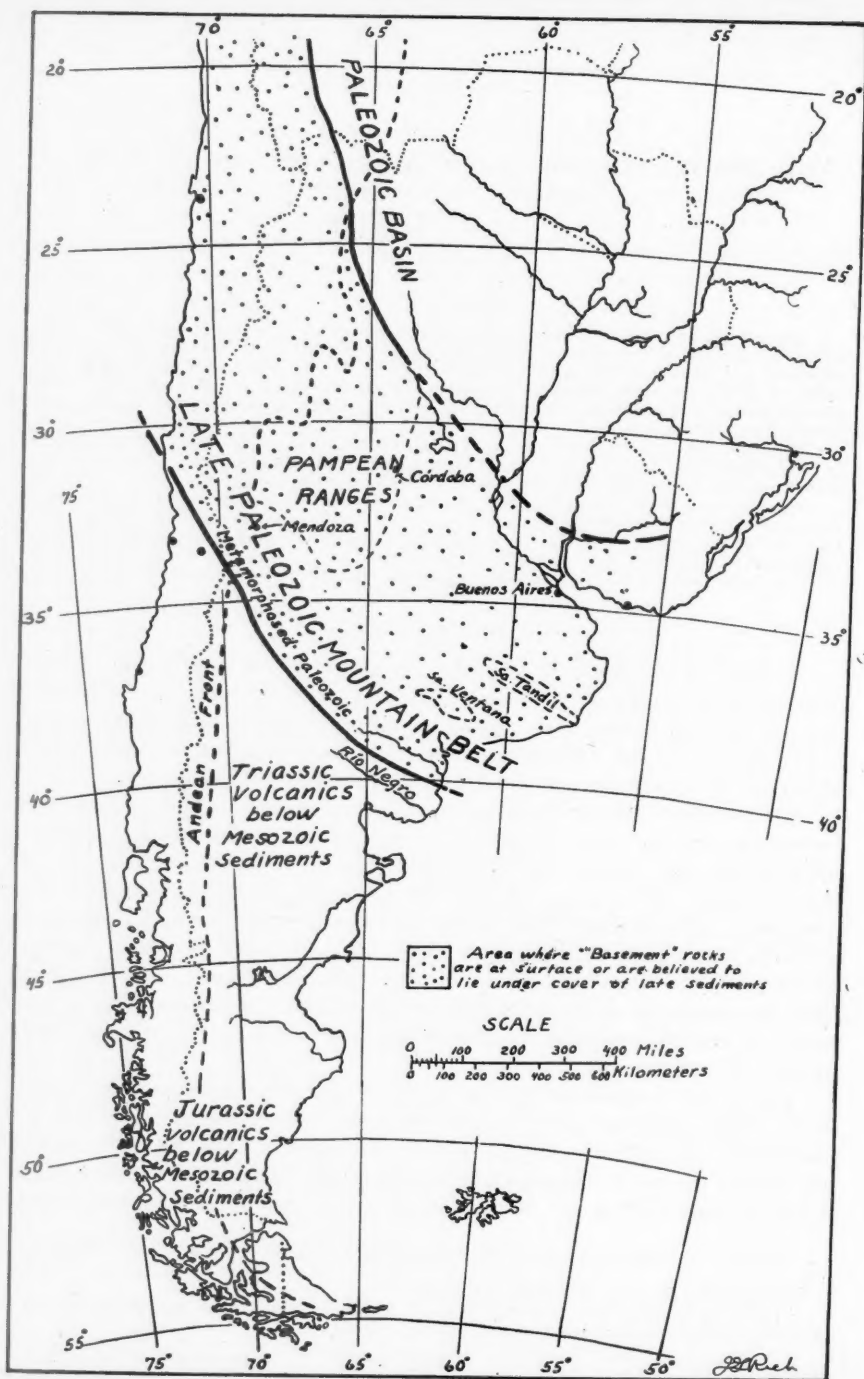


FIG. 1.—Paleogeographic features of southern South America. Probable area affected by Late Paleozoic mountain building, with metamorphosed belt along its southwestern border, Early Mesozoic volcanics south of it, and deep Paleozoic sedimentary basin northeast.

Andes, north through Bolivia, Peru, Ecuador, and Colombia, and thence east through Venezuela to Trinidad. Turning then back westward, we consider the Maracaibo basin, northern and western Colombia, Ecuador, and northwestern Peru, from which we jump to the lower Amazon trough, then to the Piauí basin—the Meio Norte, or Middle North as the Brazilians call it. Continuing eastward, we examine the conditions in the coastal region of northeastern Brazil and, finally, those of the great Paraná basin of southern Brazil and adjoining countries.

ACKNOWLEDGMENTS

The appended bibliography makes no pretense of completeness, but cites the principal sources used in the present study, and should serve as a starting point for students desiring to pursue the subject further.

Except for names commonly Anglicized, place names and accents follow the usage of the American Geographical Society in its 1:1 million and 1:5 million maps. Grateful acknowledgment is made to the American Geographical Society for permission to reproduce from "The Face of South America" the photograph for Figure 16, and from the *Geographical Review* the photograph for Figure 11; also to the Servicio Aerofotográfico Nacional of Peru for permission to use the photograph of Figure 11.

SOUTHERN SOUTH AMERICA

Since paleogeography and a knowledge of the sinking and filling of sedimentary basins and troughs are fundamental to petroleum geology, a convenient starting point for South America is the Late Paleozoic mountain mass already mentioned.

LATE PALEOZOIC MOUNTAIN BELT

Extending west and northwest across Argentina from the Atlantic Coast south of Buenos Aires into northern Chile, it forms a belt (Fig. 1) about 200 to 500 miles wide in which ancient crystalline or metamorphosed Paleozoic rocks are at the surface or are believed to be buried under a comparatively thin covering of Late Tertiary and Quaternary rocks. In the eastern part, in the province of Buenos Aires, two groups of low hills, the Sierra Ventana and the Sierra Tandil, representing the ancient mountains, project above a mantle of Late Tertiary sediments. In them Paleozoic sediments ranging in age up to and including Permian are highly deformed and considerably metamorphosed, with structure indicating pressure from the southwest (DuToit, 1927; Riggi, 1938). Where the central part of the belt crosses the Andes between Latitudes 28° S. and 30° S., available maps fail to show Paleozoic rocks, and the crystalline basement rocks are at the surface.

East of the Andes, the ancient mountain belt is occupied by the so-called Pampean Ranges—the Sierra de Córdoba, Sierra San Luis, Sierra Famatina, and several others. The Pampean Ranges rise as fault-bounded blocks above a mantle of Late Tertiary and Quaternary gravels and sands. On the flanks of some of

them are exposed unmetamorphosed continental sediments of Carboniferous and Permian age lying unconformably on the basement crystalline rocks; and around some of the ranges, possibly conformable above the Permian, are coarse fanglomerates of Triassic age.

Along the southern and western side of the old mountain belt stretching in a southwestward-convex curve from the mountain remnants near the east coast in Buenos Aires Province, across the Territory of La Pampa, and the provinces of Mendoza, San Juan, and La Rioja, and probably extending thence northward in western Chile, the old Paleozoic rocks, including the Devonian, have been more or less highly metamorphosed. This condition, combined with the evidence of pressure from the south in the mountain remnants of Buenos Aires Province, strongly suggests that along the whole Late Paleozoic mountain belt the pressures were from the south and west, and the sediments on the southwest side of the mountain region were metamorphosed while those on the northeast side were not. The situation seems to be somewhat similar to that in the Appalachians where, during the Late Paleozoic period of mountain building, the pressures were directed from the east, and along that side sediments were metamorphosed, whereas on the Appalachian foreland at the west they were not.

It will be clear from the foregoing that there is little prospect of finding oil in any of the Paleozoic rocks in the old mountain belt under discussion except, perhaps, in Carboniferous and Permian sediments under the bolsons between the Pampean Ranges in the northern part of the belt east of the Andes.

Nor are there rocks younger than Paleozoic that might contain oil except for: (a) rocks of Rhaetic age overlapping the southwestern side of the belt that have been found to be oil-bearing in the Mendoza region, and (b) marine Miocene and perhaps earlier Tertiary rocks that fill the Paraná trough of Argentina to an unknown depth west and northwest of Buenos Aires (Fig. 7).

The old mountain belt thus described separates southern South America into two distinct provinces so far as oil and gas possibilities are concerned. One at the south depends on Late Triassic, Jurassic, and Cretaceous rocks, and the other, at the north, derives its oil possibilities from a thick section of unmetamorphosed Devonian sediments and overlying Carboniferous and Permian rocks that lies north of the old mountain belt under discussion.

SOUTHERN ARGENTINA AND CHILE

Following the Late Paleozoic diastrophism which produced the old mountain belt, volcanism on a large scale broke out in the region south of that belt, spreading widely a thick series of lava flows, agglomerates, and tuffs. These volcanic rocks range in age from Triassic at the north to early Jurassic in southern Patagonia and Tierra del Fuego. In the western part of the region, approximately along the position of the present eastern front of the Andes, the volcanic rocks, resting directly on the crystalline basement or on metamorphic rocks of possible Paleozoic age, appear to have been continuous from the vicinity of Mendoza to

Cape Horn, but in a large area in northern Patagonia, stretching roughly from the Río Negro south to Lat. 44° , the volcanic rocks either were never deposited or have since been removed.⁴

Volcanism was followed by a general settling of the region, by an encroachment of the sea from the west, and by an especially great settling of certain troughs and basins at intervals throughout the Mesozoic and Tertiary. In this way several thick accumulations of sediments were formed in regions of exceptional sinking that have already yielded three important oil-producing districts and give promise of yielding others when more fully explored and tested. Post-Permian deformation of the region south of the Late Paleozoic mountain belt seems to have been in the nature of block faulting of "Great Basin" type superimposed on broad warpings of the sort which permitted the sea encroachments and the formation of the major sedimentary basins already mentioned.

MENDOZA DISTRICT

The earliest of these basins lies in the Province of Mendoza where, in the later part of the Triassic (Rhaetic), the sinking associated with the encroachment of the sea from the west permitted continental sediments of fluvial origin, admixed with large amounts of tuff and volcanic ash (Fig. 2), to accumulate to a thickness which, though highly variable, locally reaches more than 4,600 feet (Baldwin, 1944). The sediments are believed to be entirely continental but they contain highly bituminous shales, particularly the Cacheuta shale, with thickness varying from 230 to 1,070 feet in various wells. One bed of this shale has been used on a small scale for the distillation of oil. Great variations in thickness of the Rhaetic formations on the various structures where it has been drilled in the Mendoza district suggest that differential movement of local blocks and basins was in progress during deposition. In the Barrancas field on the fold most distant from the Andes, only about 970 feet of the Rhaetic sediments are present, while on one on the nearer folds more than 4,600 feet were drilled without reaching the bottom. The results of test drilling suggest that the Rhaetic sediments may not extend—or at least do not cap the anticlinal structures—more than a few miles east of the localities where they have been proved oil-productive south of the city of Mendoza.

The Mendoza oil fields,⁵ now at least five in number, are producing on folded structures all within 35 miles of the eastern base of the Andes. The oil in the various fields occurs at different horizons ranging from the weathered upper part of the underlying Triassic volcanic series up to a horizon relatively near the top of the Rhaetic and at least 2,300 feet above the top of the Cacheuta shale, which is generally looked upon as being the most probable source of the oil occurring both above and below it.

⁴ Much of the best available late material on Argentina may be found scattered through the reports of the first two annual conferences of the geologists of the Argentine Government oil company (Y.P.F.) published in *Boletín Informaciones Petroleras* as follows: Vol. 15 (1938), No. 171; Vol. 16, No. 180 (August, 1939), pp. 3-21.

⁵ For the latest and most complete description, see Baldwin (1944).

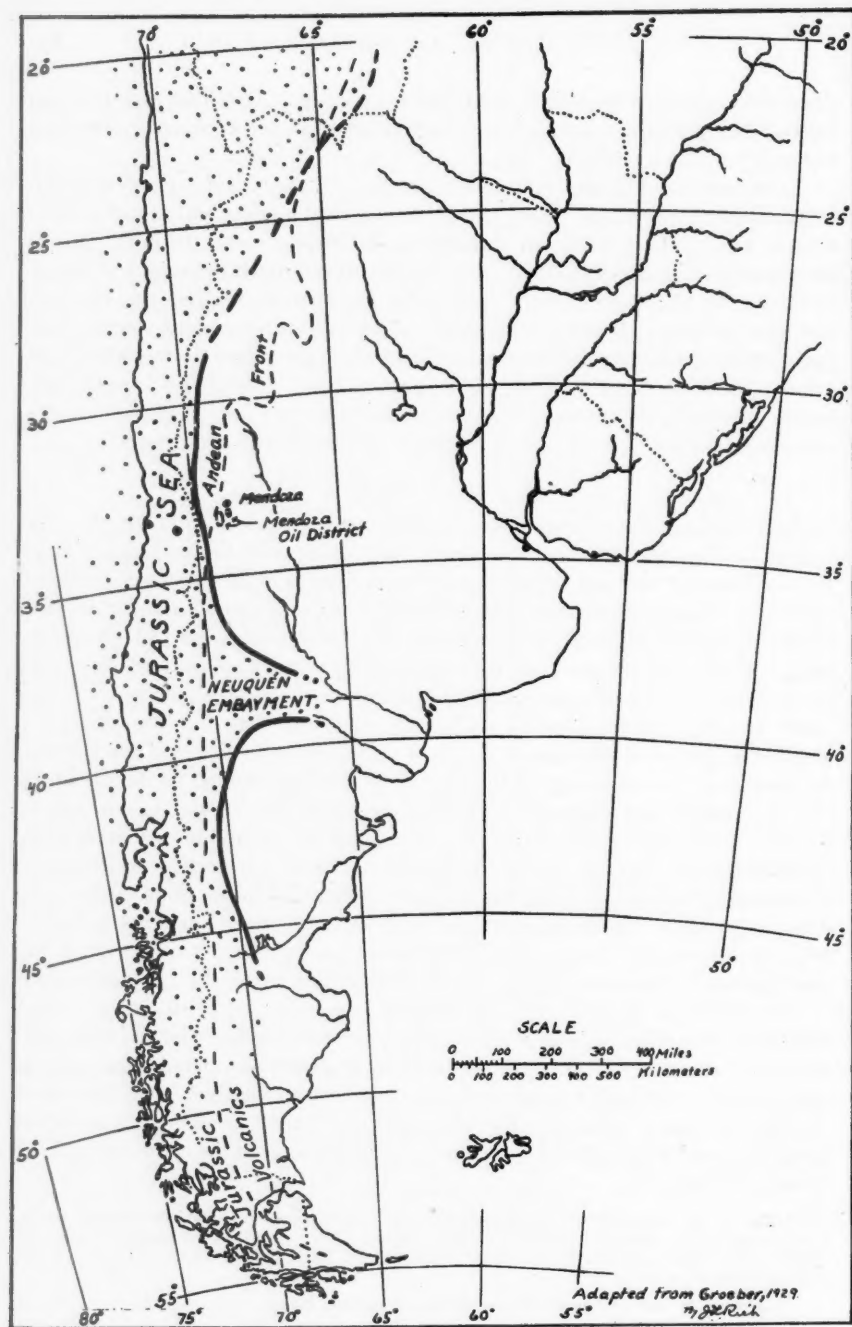


FIG. 4.—Paleogeography of Jurassic in Argentina and Chile.
(Adapted from Groeber, 1929.)

In the Tupungato field (Fig. 3), the one which has been most productive to date, the oil comes from fissures in hard volcanic tuff somewhat more than 1,000 feet thick, with interbedded shales.

The occurrence of oil in the Rhaetic sediments of the Mendoza region raises an interesting problem of source beds. All of the rocks in the section are believed to be continental in origin. Below the Rhaetic are only lavas and metamorphosed Paleozoic rocks, and above it are only continental sands, shales, gravels, and tuffs of Tertiary age.

The Rhaetic beds which produce oil in the Mendoza district do not seem to have extended far, if at all, south of the Province of Mendoza. Not enough information is at hand to justify any statement as to the possibilities of finding other fields in the Mendoza district. The rapid thinning of the Rhaetic sediments on the crests of the structures as one proceeds eastward from the Andes is discouraging, but if, as is suggested by observed conditions, block faulting and basin formation were in progress during Rhaetic time, Rhaetic sediments bearing oil may be present in the basins on the east, even though they may be absent on the major structures. Finding any such oil pools will, however, present rather formidable difficulties.

NEUQUÉN EMBAYMENT⁶

During the Jurassic, the subsidence of western South America, begun in the Upper Triassic, continued and spread. The area which sank beneath the sea appears to have included all of Chile and to have extended for some variable distances eastward into western Argentina. By the beginning of the Cretaceous the sea covered essentially the area indicated in Figure 4 (modified from Groeber, 1929), and in it there accumulated considerable thicknesses of marine limestones and shales and also, locally, extensive beds of sandstone and gypsum. But in southern Patagonia, during the Jurassic, volcanic rocks of the effusive type were spread out over the basement crystalline and metamorphic rocks.

During the Jurassic, and continuing into the Cretaceous, a trough of excessive subsidence developed at about Lat. 38° S. in what is now the Territory of Neuquén, Argentina. The resulting embayment, about 150 miles wide, extended for at least an equal distance east of the general line of the Jurassic coast, and perhaps as far east as the present site of the Atlantic coast. In it was accumulated a section of marine Jurassic and Cretaceous rocks aggregating about 7,000 feet in thickness.

It is worthy of note that the position and course of the Neuquén embayment is such as to suggest that the subsidence occurred along the southwestern border of the Late Paleozoic zone of mountain building indicated in Figure 1. It is not yet known how far east the embayment extended, for its sediments are buried on the east under an unconformable cover of later rocks. Groeber (1929, pp. 60-63)

⁶ Useful references not referred to specifically in the text are: Lahee (1927); Groeber (1933); Gerth (1935); Roll (1939).

suggests a genetic relation to the Late Paleozoic orogenic belt here referred to, and gives faunal evidence to support his suspicion that in Jurassic and Lower Cretaceous time the embayment may have continued southeast far enough to connect with the Atlantic of that day.

In mid-Cretaceous time the Jurassic and early Cretaceous sediments of the Neuquén embayment were involved in crustal movements, apparently of the block-fault type, and were partly eroded from the uplifted blocks before Late Cretaceous sediments were deposited unconformably over them. The western part of the embayment was later subjected to the full force of the Andean orogeny which began with the Tertiary period. The Andean folding was so intense as to preclude the possibility of oil being found in the mountains, but the folds die out not far eastward and produce favorable structures.

In the Neuquén embayment, east of the Andes, several important oil fields have been developed, of which the Plaza Huincul field is the oldest and best known. Apparently, in the fields opened to date, structures developed during the mid-Cretaceous crustal movements have been more significant in controlling oil accumulation than those originating during the Andean orogeny.

Though the Neuquén embayment as now exploited for oil is of relatively small dimensions, sedimentary and structural conditions favor the expectation that a considerable number of other fields will be found within it. If, as Groeber suspects, the embayment is really a trough connecting all the way through to the Atlantic, the prospective oil territory would be greatly increased.

Examination of Figure 4, on which the eastern front of the Andes is shown by a dashed line, will show why it is that the Neuquén embayment seems to be the only place in southern South America where oil may reasonably be expected in sediments resulting from the Jurassic submergence of the western part of the continent in Argentina and Chile. The only place where the sites of Jurassic sedimentation extended east of the present mountain front is in the Neuquén trough and in a narrow strip south of it where Groeber's maps indicate the presence of neritic sediments of Jurassic age.

No oil fields can be expected in the highly deformed Andes mountain region, and the Jurassic rocks that presumably once existed in the Chilean coastal zone west of the Andes have also been intensely deformed and so much eroded that only scattered fragments remain—in no condition to offer any attraction to the oil geologist.

It does not seem certain, however, that the portion of the region east of the Andes that lies south of the Neuquén embayment is entirely without possibilities for oil in Jurassic rocks. As Groeber suggests, the Jurassic shore line in that region may have been drawn too far west, for, in places at least, the present eastern border of the Jurassic sediments is erosional and the distance eastward to which they may once have extended is problematical. The Jurassic shore line, therefore, may actually have been some distance east of where he has drawn it and, if that is so, undiscovered down-warped areas of Jurassic sediments may exist, which would have oil possibilities.

The oil in the Neuquén fields is being produced mainly, if not entirely, from Jurassic rocks under a variety of structural conditions which involve complexities, such as buried hills and the effects of inter-Cretaceous crustal movements, whose discussion would require entering into details that would be out of place in this paper (see Baldwin, 1942).

Suffice it to say that the complexities are great enough and that enough likely oil territory is obscured by a cover of later sediments and lava flows to make it certain that much remains to be done before the oil possibilities of the Neuquén embayment are exhausted. Besides, in some of the fields, oil has been found in Cretaceous rocks but has not yet been developed because those rocks are too tight to produce naturally. It is hoped that they may be made productive by shooting.

CRETACEOUS TROUGH OF SOUTHERN PATAGONIA AND TIERRA
DEL FUEGO (MAGALLANES BASIN)

In the eastern Andes of Argentina and on the plains at their foot, all the way from about Lat. 44° S. to the eastern tip of Tierra del Fuego, there is a thick series of marine Cretaceous clays, shales, and sandstones ranging in age from lowest Cretaceous (Tithonian), or even the upper part of the Jurassic, up to Albian at the north and including probably the entire Senonian at the south (Feruglio, 1938, p. 57). The total thickness of the series near Lago San Martín (Lat. 49° S.) is described as more than 6,000 feet, of which about 2,300 feet consists of dark marly shales and limestones. Most of the remainder is sandstone (Gerth, 1935).

It should be noted, however, that the sea in which these Cretaceous rocks were deposited (Fig. 5) is believed to have invaded from the west or southwest and that, especially in the northern part of the area under discussion, the section as exposed in the foothills of the Andes thins out not far east and northeast. In the southeastern part of the Territory of Santa Cruz and, no doubt under all of extra-Andean Magallanes and Tierra del Fuego, the Cretaceous rocks, under cover, reach to the Atlantic coast, but in the north with much reduced thickness. This was proved by wells at Pto. Coyle (Lat. $50^{\circ} 54'$ S.), and near Gallegos (Lat. $51^{\circ} 42'$ S.), as reported by Feruglio (1938, p. 59), and by Ruby (1944). In the last-named locality, Tertiary sediments extend to a depth of 650 meters and are underlain by an equal thickness of sediments which fossil evidence, as interpreted by Feruglio, indicates comprise the entire Cretaceous section. These rest, at a depth of 1,300 meters, on the Jurassic lava series already mentioned.

The thinning of the Cretaceous section from more than 6,000 feet near Lago San Martín to about 2,100 feet at Gallegos, in a distance of about 235 miles, is notable. But though so greatly thinned, the Cretaceous along the Atlantic coast in southern Patagonia is still thick enough to be of interest, for it constitutes the updip wedge of a favorable geological section that is much thicker on the west and southwest.

Farther south, the presence of an exceptionally deep sedimentary basin, cen-

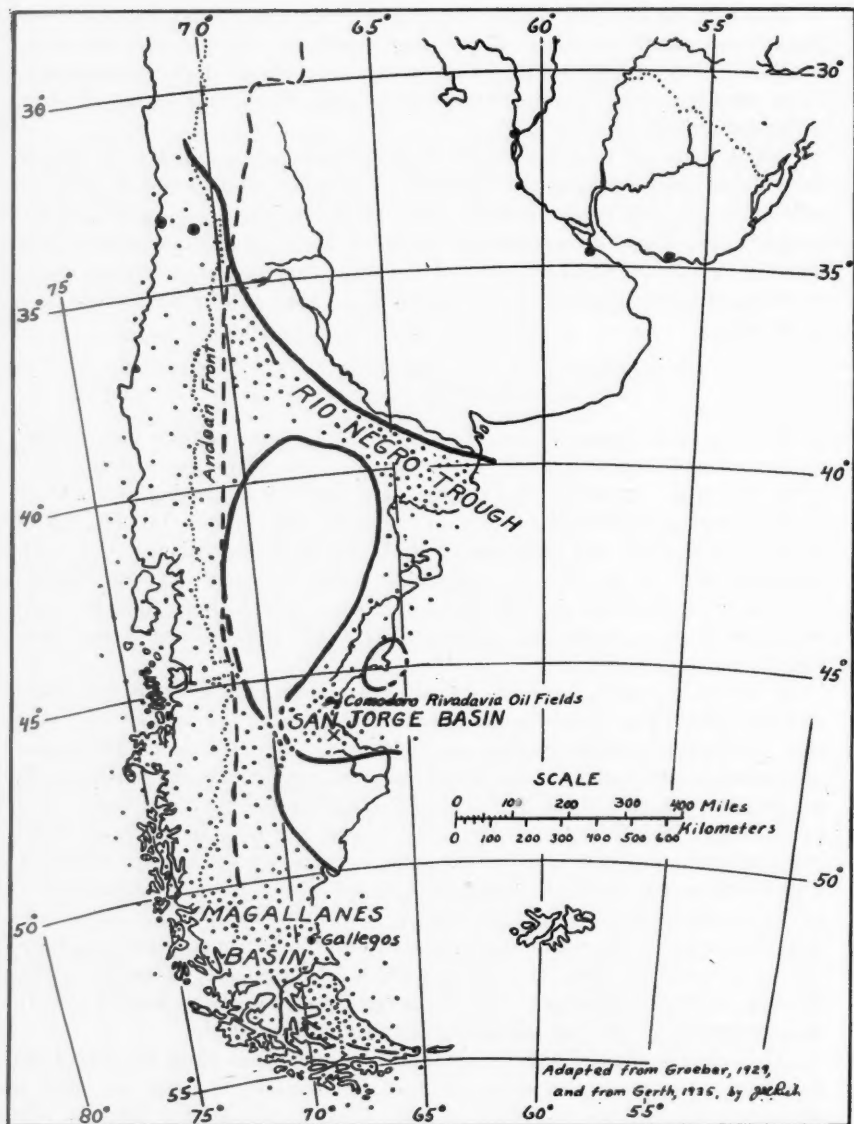


FIG. 5.—Paleogeography of Cretaceous of Argentina and Chile. (Adapted from Groeber, 1929, and Gerth, 1935.) In general, Cretaceous rocks in western part of area are older than those in eastern.

tering apparently somewhere along the Straits of Magellan, is indicated by Ruby (*op. cit.*, 1944) who states that only a few kilometers south of the 52d parallel (and by inference roughly 50 miles southwest of the Gallegos well) "continuous seismograph reflections, apparently all from sediments, have been observed to depths below 4,000 meters." He states that in the mountains on the west geologists have measured approximately 2,000 meters of Lower (?) Cretaceous, without finding the bottom, and that the Upper Cretaceous shows a measurable thickness of at least 6,000 meters.

In Magallanes Province of Chile, part of which seems to coincide with the deepest part of this sedimentary basin, oil-stained sands and seepages have been found on the anticlines near the mountains, and a small amount of oil was found about 15 years ago in a well at Tres Puentes near the city of Puenta Arenas (Magallanes).

This thick accumulation of Cretaceous rocks in what may be called the Magallanes basin (but has generally been referred to in Argentina as the Santa Cruz basin), is separated from the Neuquén embayment by a long stretch where the Jurassic and Cretaceous marine deposits apparently never extended much if any east of the present Andes Mountains, and it is bounded on the north in Patagonia by a positive area, occupying a large part of the Territory of Santa Cruz, where the Jurassic lavas and even the underlying crystalline basement rocks appear at the surface.

The oil possibilities of the Magallanes basin seem good. Close to the Andes the Cretaceous rocks are strongly folded, but the best evidence indicates that the folds die out not far away from the mountains. Under the plains bordering the Atlantic the Cretaceous rocks are overlain by a considerable thickness of marine Tertiary sediments that, in themselves, may have some oil possibilities. In the foothills of the mountains, structures can be worked from the surface, but working conditions are difficult on account of dense vegetation and a cover of glacial deposits. On the plains bordering the Atlantic, geophysical methods of exploration will doubtless be the main reliance for preliminary exploration.

SAN JORGE BASIN⁷

North of the Magallanes basin, and covering much of the north-central part of Santa Cruz Territory, is a positive area where the Jurassic volcanic rocks and the underlying crystalline rocks of the pre-Mesozoic basement lie at, or a short distance below, the surface. North of this, between it and a similar positive area occupying much of Chubut Territory, lies the San Jorge basin (Fig. 5), extending inland with a roughly semi-circular shape from the head of the Golfo de San Jorge.

Argentina's oldest and most important oil fields—those of the Comodoro Rivadavia district—are located along the northern flank of this basin. Thirteen or more pools of various sizes now comprise the district.

⁷ General references: Fossa-Mancini (1935, 1938); Rossbach (1930).

The sediments in the basin are thick. For example, a deep well starting not far above sea-level 4 miles north-northeast of the town of Comodoro Rivadavia showed approximately 5,900 feet of sediments overlying the Jura-Triassic tuff or quartz porphyry, not including about 1,500 feet of section represented by the relief of parts of the basin.

The lower 4,000 feet or more of sediments in the basin, beginning about 3,000 feet below the surface on the higher ground and 2,000 on the lower, belong to the so-called Chubut formation, which is the oil-producing formation in the Comodoro Rivadavia fields. The Chubut formation is composed of clays, shales, and sands mainly continental in origin but with scattered intercalations of marine beds. It has generally been assigned to the Middle and Upper Cretaceous, but Ruby (1944) states that there is no valid reason for assigning an age so late. The Chubut formation is overlain, with unconformity, by about 800 feet of marine Upper Cretaceous shales—the Salamanca formation—and these in turn by a succession of continental Eocene, marine Oligocene and Miocene, and continental Pliocene and Quaternary sediments (Fig. 6).

Most of the oil in the Comodoro Rivadavia fields is produced from the upper 200 feet of the Chubut formation, but some of it comes from the lower part of the overlying formation and, in the outlying fields, from deeper in the Chubut formation, locally as much as 2,000 feet below the top. Accumulation of oil is controlled in part by anticlinal or domal structures, in part by fault traps, and in both by irregularities in porosity. Actually, a considerable part of the accumulation seems to be entirely controlled by sand lenses, probably partly of the off-shore sand-bar type.

The portion of the San Jorge basin in which oil may be expected extends about 70 miles west from the head of the Golfo de San Jorge and an equal distance north-south along the coast. Until recently, commercial oil fields had been found only on the northern flank of the basin, though showings have been found in many of the unsuccessful test wells in other parts.

On June 26, 1944, a discovery of the greatest importance for the prospective oil future of the San Jorge basin was made when a new well was completed on the southern flank of the basin (at X of Fig. 5) at Lat. $46^{\circ} 33\frac{1}{2}'$ S., Long. $67^{\circ} 38'$ W., about 10 miles southwest of the coast at Caleta Olivia and about 50 miles south of the older fields (*Bol. Inf. Petrol.*, Vol. 21, July, 1944, pp. 74-75). The discovery well showed several oil-bearing formations above the one in which it was completed, flowing naturally 1,006 barrels (160 cubic meters) per day of light oil of specific gravity 0.873, from 5,251-5,260 feet. This discovery opens the possibility, if not the probability, that a considerable part of the basin may ultimately be productive.

RÍO NEGRO TROUGH

During latest Cretaceous time the sea invaded southern Argentina from the east, and marine sediments of dominantly shaly type were deposited in the three

areas of that region that had already demonstrated "negative" tendencies, namely, the Magallanes basin, the San Jorge basin, and a long, relatively narrow trough, extending northwest from the head of Golfo San Matías, that may be called the Río Negro trough (Fig. 5, modified in this locality after Gerth, 1935, p. 310).

In the Magallanes basin the sediments accumulated at this time merge into the thick Cretaceous section already described. In the San Jorge basin they constitute the Salamanca formation consisting of about 800 feet of dominantly shaly marine sediments that lie immediately above the principal petroliferous formation—the Chubut—and which themselves contain oil in their lower part in some of the fields, and by some authors (for example, Rossbach, 1939) are looked upon as the most probable source of most of the oil in that basin. In the Río Negro trough the submergence was sufficient to permit marine waters to penetrate inland from the Atlantic to beyond the present eastern border of the Andes.

Marine sediments of this age also fill a trough parallel with the coast connecting the San Jorge basin with the Río Negro trough.

Not much is yet known about the sedimentary filling of the Río Negro trough. It will be noted that the western end of that trough, as shown in Figure 5, coincides approximately with the position of the Neuquén embayment during the Jurassic and Lower Cretaceous as shown in Figure 4 and that the pattern of the Neuquén embayment and certain fossil evidence suggest the continuation of that embayment toward the southeast. The fact that essentially the same trough was the site of subsidence in the latest Cretaceous suggests that it may have been a generally subsiding element throughout Jurassic and Cretaceous time and that, therefore, it may hold not only the equivalents of the Chubut formation of the San Jorge trough but also Lower Cretaceous and Jurassic sediments.

We must conclude, therefore, that on the basis of present information the Río Negro trough must be considered to hold unknown, but possibly great, oil possibilities.

TERTIARY ROCKS IN ARGENTINA

In the part of Argentina south of the Late Paleozoic mountain system, continental and marine Tertiary sediments reach a thickness of more than 2,000 feet in the Comodoro Rivadavia region and farther north, but presumably hold no prospects of being oil-bearing. In southern Santa Cruz and in Tierra del Fuego, however, marine Tertiary rocks, reaching a thickness of more than 2,000 feet, possibly contain oil, as already suggested.

In the latter part of the Tertiary period in western Argentina all the way from the Straits of Magellan and beyond to the Bolivian border, great accumulations, consisting mainly of gravel and sand, were spread out from the growing Andes mountain range over the plains on the east.

In the western part of southern Argentina, one of the principal effects of the accumulation of the Late Tertiary gravels has been to mask the underlying

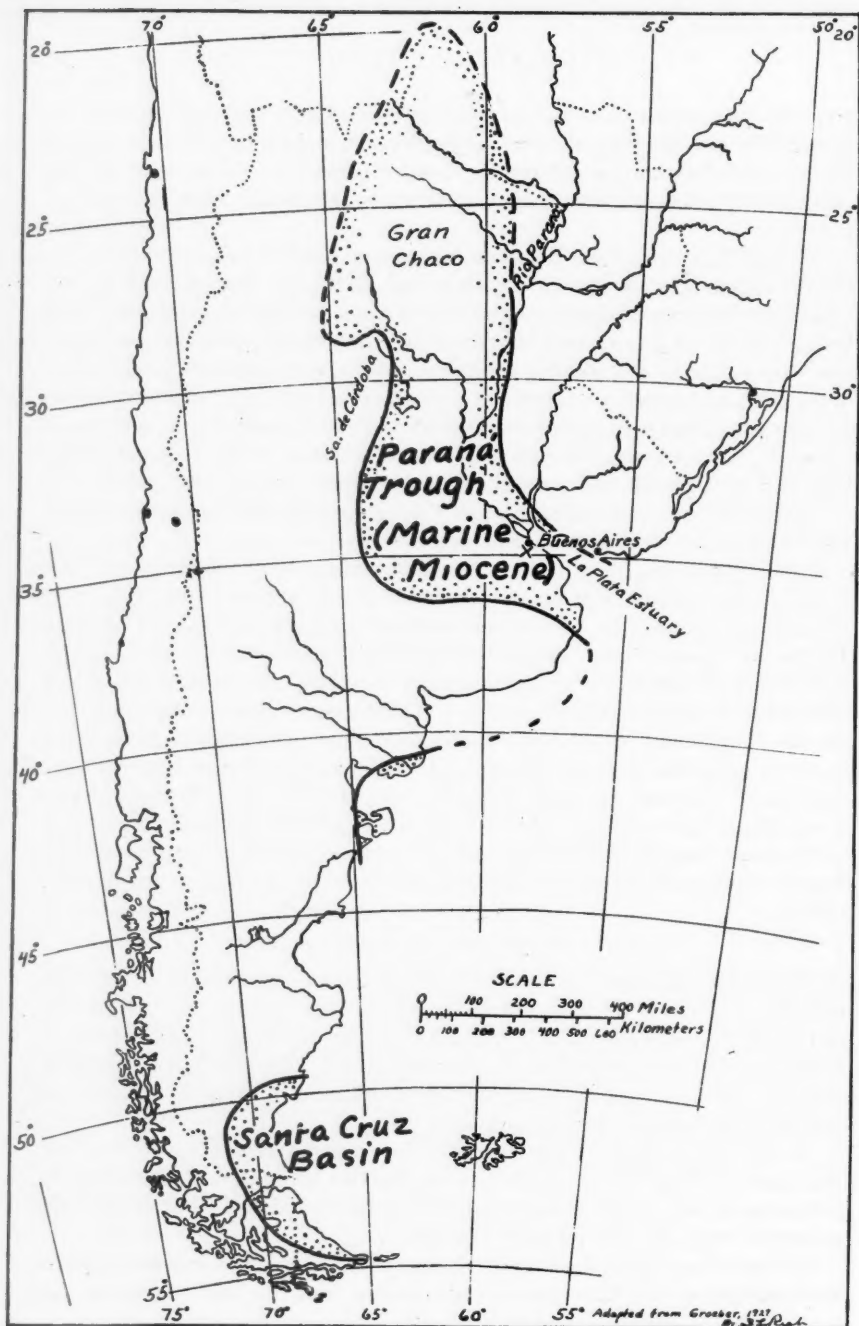


FIG. 7.—Paraná trough, a Miocene embayment.
(Adapted from Groeber, 1929.)

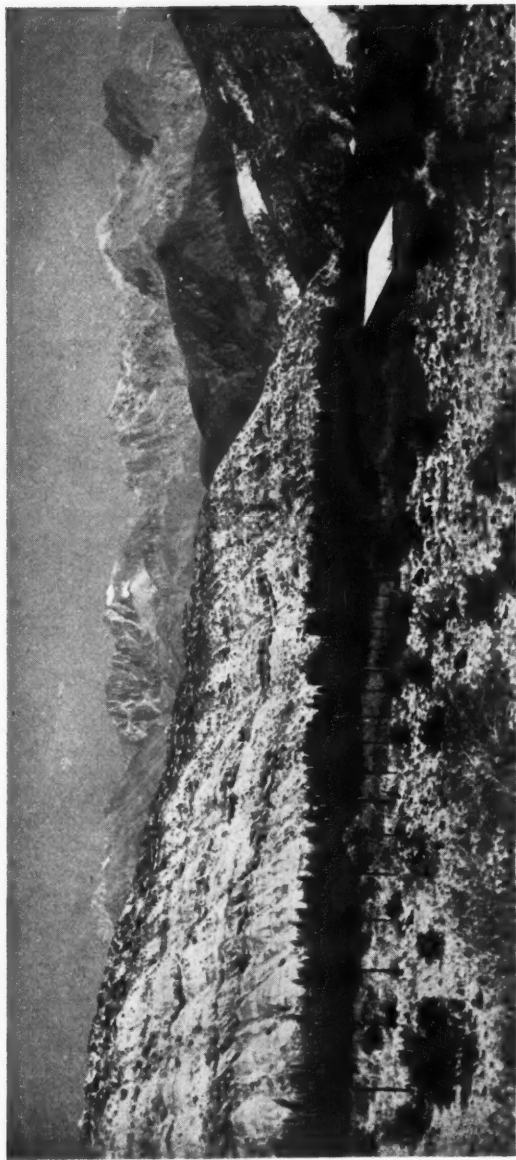


FIG. 2.—Exposure of Rhaetic rocks at Potrerillos in foothills of Andes southwest of Mendoza, only 6 miles from where same strata are producing oil in Cacheuta field. Oil shale member of Cacheuta shale crops out in face of escarpment. Much of exposed rock is tuffaceous. High Andes in background.

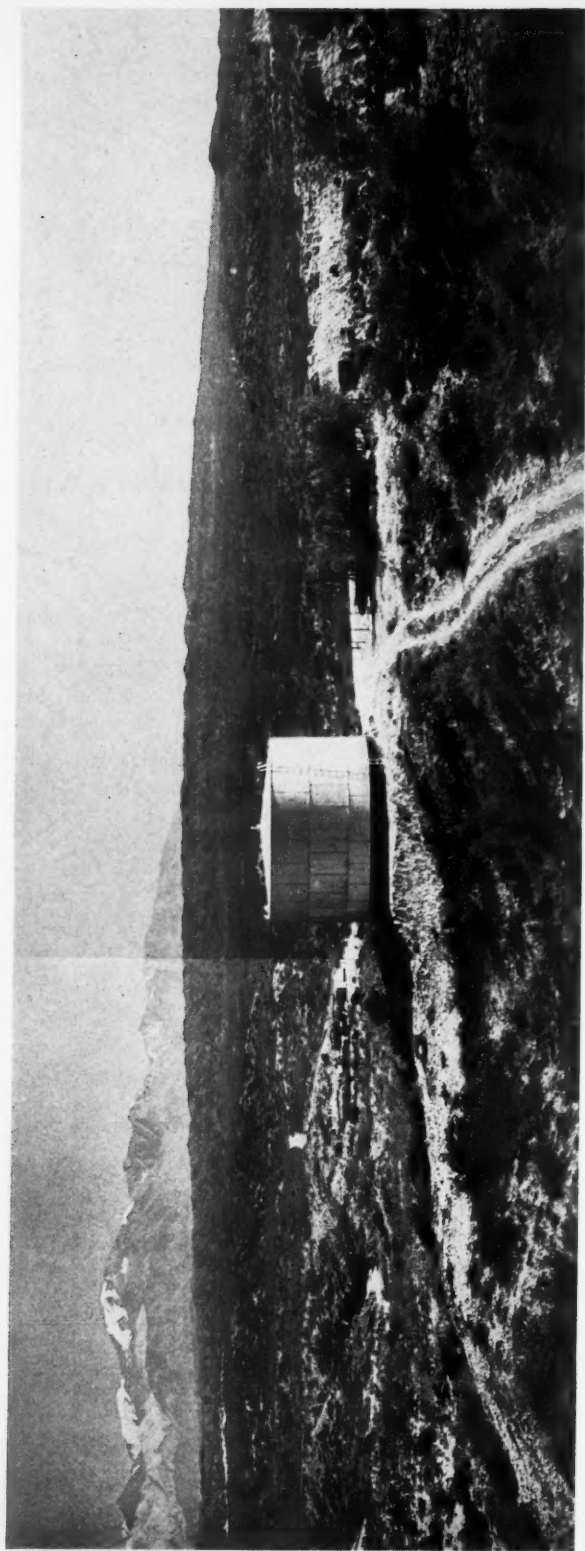


FIG. 3.—Panorama northwest from western rim of Tupungato dome. Refugio dome, now producing, is visible beyond oil tank. West-dipping flank of Tupungato structure appears in right foreground.

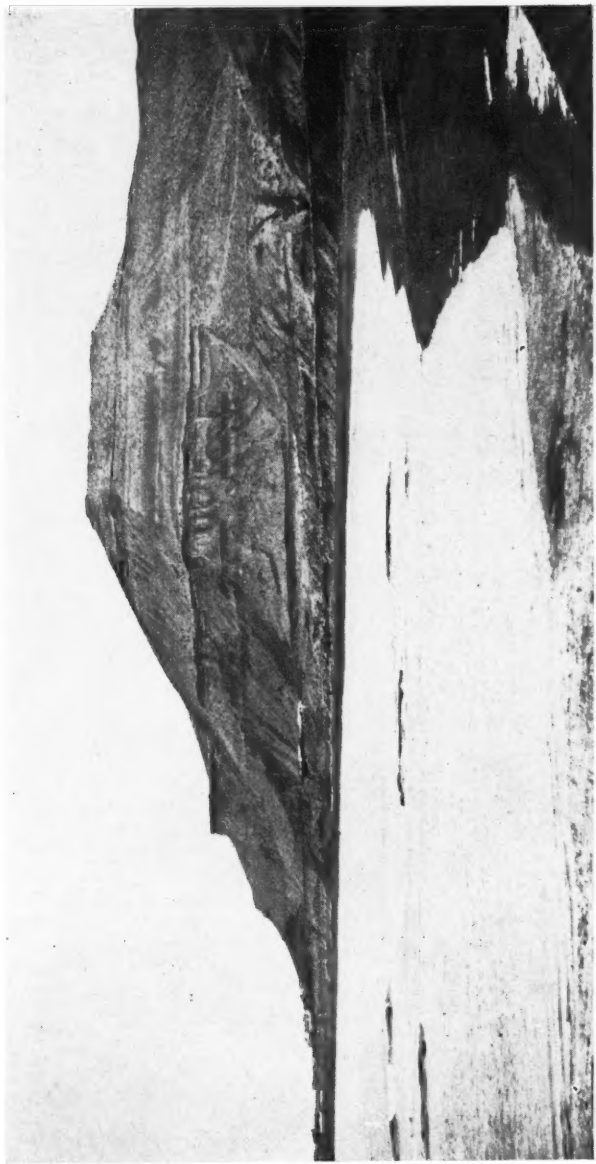


FIG. 6.—Late Tertiary rocks at Comodoro Rivadavia, Argentina.

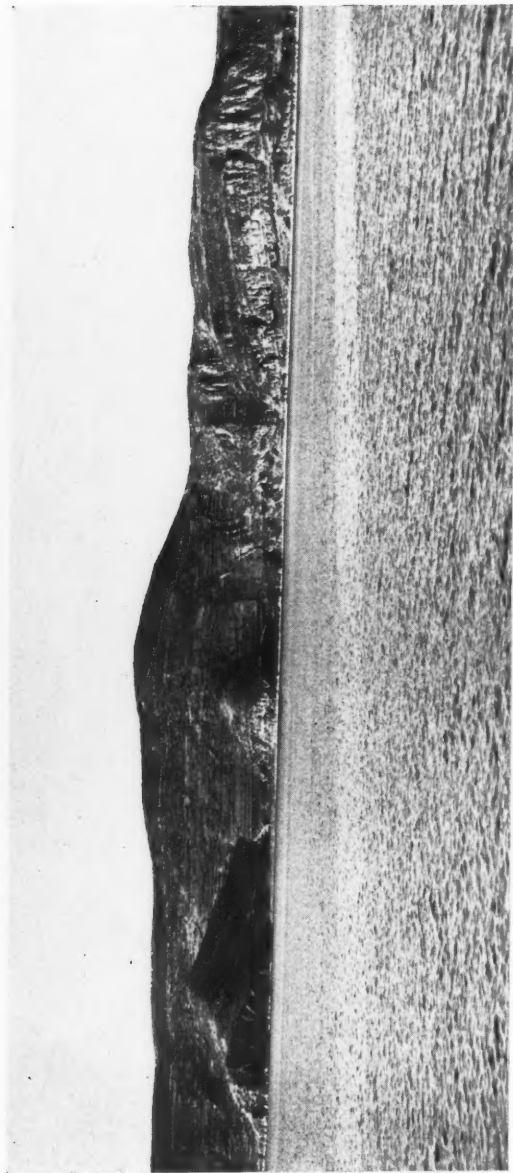


FIG. 9.—Typical exposures and structure of Paleozoic rocks on Andean plateau: Carboniferous rocks near southern end of Titicaca Island in Lake Titicaca.

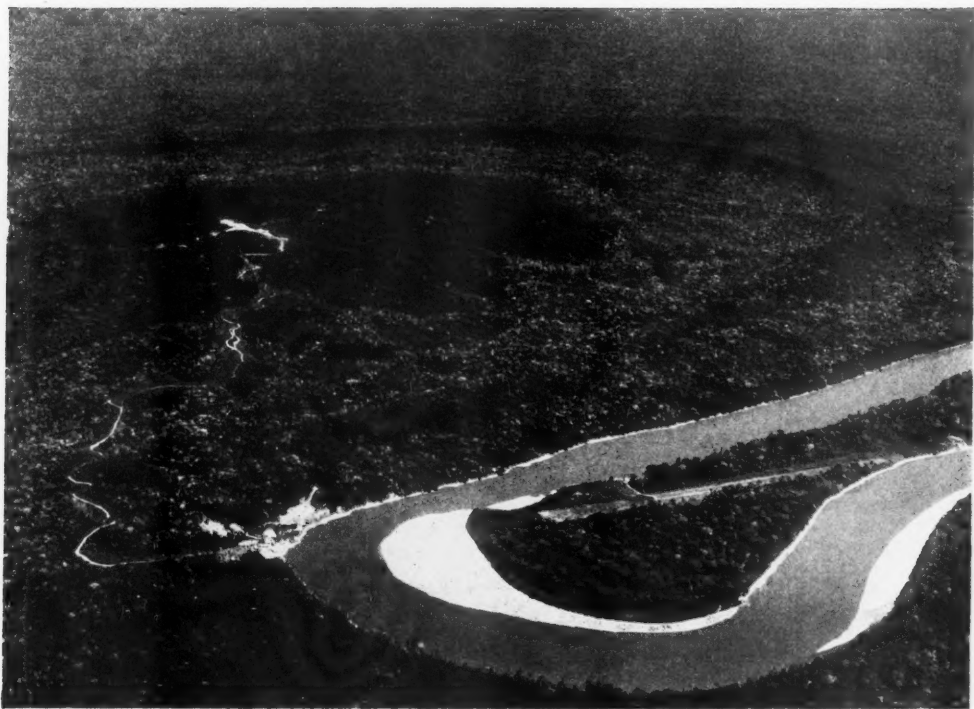


FIG. 11.—Agua Caliente dome, site of Peru's first oil field east of Andes. Structure revealed by topography and vegetation despite cover of tropical rainforest. (Photo by National Aerophotographic Service of Peru, reproduced by permission of American Geographical Society.)



FIG. 14.—Looking southeast across Magdalena trough from between Girardot and Ibagué. Eastern Cordillera on far skyline. Illustrates folded and faulted minor ranges within trough, and typical semi-arid type of vegetation.

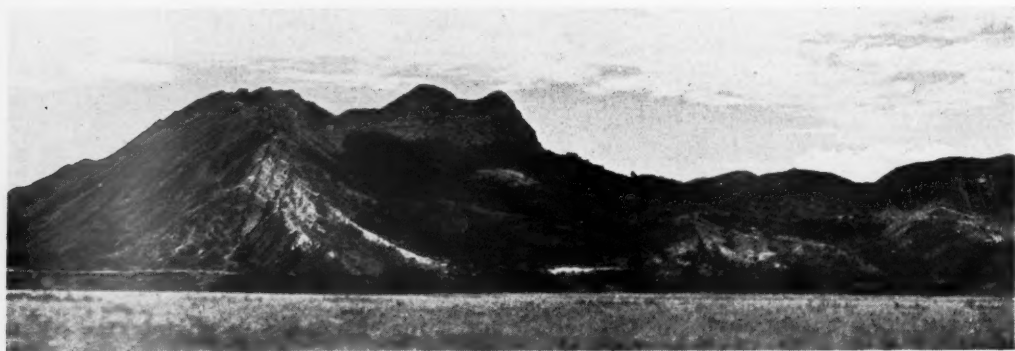


FIG. 15.—Ground view of structure of one of minor ranges within Magdalena trough near right side of Figure 14.



FIG. 16.—Looking northwest across Cauca trough from point north of Tuluá. Shows abrupt, straight west wall of graben, flat, alluviated bottom along west side, and low hills of deformed Tertiary rocks forming eastern part of trough bottom. (By permission, American Geographical Society.)

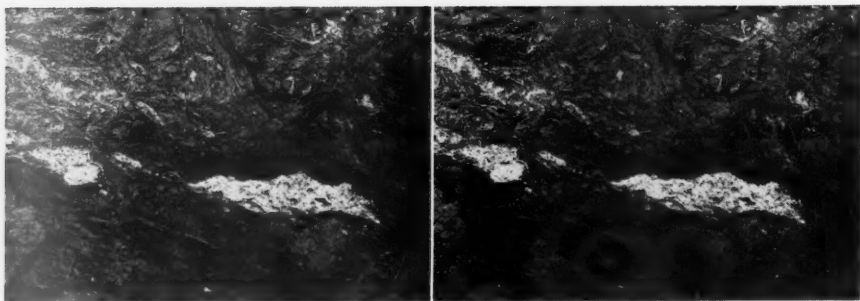


FIG. 18.—Stereoscopic view of crumpled shales in one of "clay-pebble" zones in Tertiary rocks near Talara, Peru.



FIG. 19.—Typical scene in Lobitos oil fields, Peru. Shows marine terrace surfaces at two levels and deep dissection of terraces close to sea and along larger streams. Vegetation of semi-arid type.

Mesozoic rocks and to make difficult the exploration of their structure and oil possibilities. This masking effect has been further accentuated by extensive flows of Late Tertiary-to-Recent lavas which cover large parts of southern Argentina.

The thickness of the sub-Andean Tertiary sand and gravel deposits increases northward. In the oil fields of Mendoza, these rocks range from 5,000 to 7,000 feet thick, and in the northern provinces of Argentina, close to the eastern base of the Andes, geophysical evidence indicates that they have a thickness of at least 11,000 or 12,000 feet in a trough whose deepest part lies not far from the present Andean front. The nature of these Late Tertiary rocks close to the Andean front is such that they would offer little if any prospect of being petroliferous, although oil is actually found in some of them in southern Bolivia on structures close to the mountain base. It is probable, however, that it has migrated upward from deeper rocks.

Eastward from the base of the Andes the Tertiary rocks naturally become finer, and in northern Argentina are partly lacustrine in nature in the region west and northwest of Sierra de Córdoba, and apparently merge with marine Tertiary sediments occupying a trough in which the Paraná River now lies (Fig. 7). This marine trough extended during the Miocene from the region of the Plata estuary northward toward and presumably into the Gran Chaco region of northern Argentina and western Paraguay. A few miles south of Buenos Aires (at X of Figure 7, a well 1,000 feet deep ended in marine Miocene beds (Wahnish, 1939). This indicates a considerable depth for the Paraná trough, but whether in its southern and eastern parts its depth is anywhere great enough to make it promising for oil accumulation is questionable.

There exists, however, the intriguing possibility of the occurrence of a thick section of marine Miocene rocks in the sub-Andean trough under the Chaco of western Argentina and Paraguay. The subsidence of the trough in its western part was very great, and if the subsidence was greater than could currently be filled by sediments from the Andes, marine conditions may have prevailed during the deposition of thousands of feet of sediments. At any rate, there must lie, somewhere under the Chaco, a belt where the alluvial Tertiary from the Andes interfingered with the marine sediments of the Paraná trough. In this belt there should be sand bars, sediments of coastal and lagunal type, and, it would seem, conditions highly favorable for the generation and storage of petroleum.

PALEOZOIC SEDIMENTARY BASIN OF EASTERN BOLIVIA, WESTERN PARAGUAY, AND NORTHWESTERN ARGENTINA

On the preceding pages we have discussed the major features of the geology and oil possibilities of the region south of the Late Paleozoic mountain system indicated in Figure 1. We now turn to the region north and northeast of the belt where those mountains crossed the course of the present Andes.

Previous to the Late Paleozoic orogeny and, apparently persisting even after that orogeny had spent its force, a deep geosynclinal trough or basin formed along

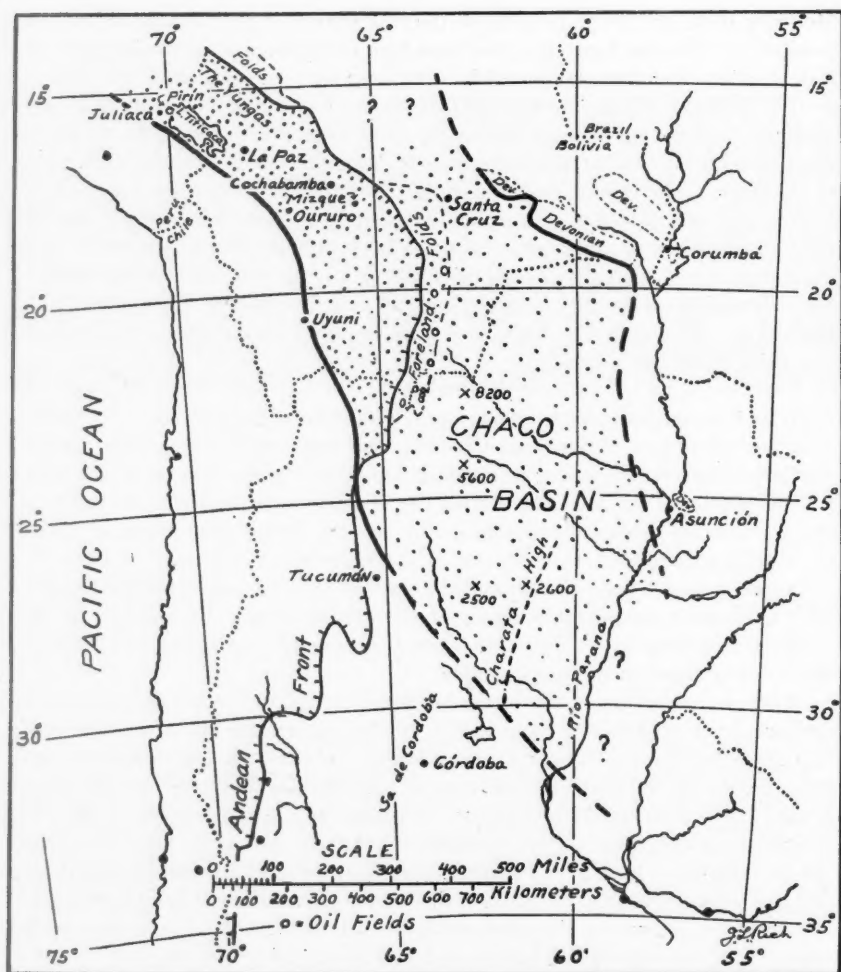


FIG. 8.—Chaco basin and Lake Titicaca region on Andean plateau. Oil fields in sub-Andean belt of Bolivia and northern Argentina and at Pirin are indicated by small circles.

the northeast side of the belt which was later to be folded by that orogeny. It covered not only much of eastern Bolivia and the western "Chaco" of Paraguay and northern Argentina, but also what is now the "Altiplano" or high Andean plateau east of a line from near Uyuni through Lake Poopo and along the west side of Lake Titicaca, and thence north into Peru (Fig. 8).

This trough received very thick deposits of dominantly marine shale and sand-

stone during the Devonian and, locally, of marine shale, sandstone, and limestone during the Carboniferous, and a thick section of dominantly continental and glacial sediments of Permian age.

As exposed in the region surrounding Lake Titicaca, east of Oruro, and at many other places on the Andean plateau, the Devonian beds include a great thickness, variously estimated as 8,000 to 15,000 feet (and doubtless varying from place to place) of dominantly shallow-water shales, sandy shales, and sandstones. A considerable part of the total thickness of the shales is black, and many beds have every appearance of being bituminous. The section appears particularly attractive as a possible source for petroleum.

Overlying the Devonian are marine Carboniferous rocks more than 2,300 feet thick in places on the Altiplano, as, for example, on Titicaca Island and the adjacent peninsulas in Lake Titicaca (Gregory, 1913) where they contain considerable dark shale and limestone (Fig. 9).

Along the eastern flank of the Andes from Tucumán, Argentina (Lat. about 27° S.), to near Santa Cruz, Bolivia (Lat. about 18° S.), a distance of about 625 miles, these Devonian and Carboniferous rocks are exposed along the mountain front and also in a belt, 30 to 60 miles wide, of anticlines of Appalachian type rising above the plains east of the high Andes. There, Heald and Mather (1922) described great thicknesses of Paleozoic rocks. At the base they estimated 3,000 to 15,000 feet of quartzites, sandstones, and shales which they tentatively assigned to the Devonian, but which later workers have found to be mainly Ordovician and Silurian. Next, above a probable unconformity, is an estimated thickness of about 10,000 feet of marine Devonian sediments consisting dominantly of dark shales with thin beds of clayey sandstones and of quartzitic sandstones, with a few beds of massive sandstone near the top. The Devonian is overlain with probable unconformity by 2,000 to 4,000 feet of dominantly sandy continental (?) beds believed to be Carboniferous. Separated from the latter by a great unconformity are 10,000 feet of massive, heavy-bedded, reddish brown or yellow sandstones, massive shales containing small glacially striated erratic boulders, and thin beds of tillite. These are believed to be Permian. Above another unconformity, about 800 feet of calcareous beds—the "lime-dolomite horizon"—constitute the most definite "marker" in the region and are believed to represent the eastern thin edge of the Jurassic-Cretaceous marine invasion which deposited thick limestones farther west. Finally, 6,000 to 10,000 feet, more or less, of red sands, clays, and conglomerates of Tertiary age represent the material washed out toward the east from the growing Andes mountain range.

The entire sedimentary section, if computed by adding the figures thus cited, appears to be somewhat more than 40,000 feet in thickness. Since most of the formational units probably thin toward the east, and since the measurements on the older beds were made farther west than those of the younger ones, the actual thickness of the sedimentary column under the eastern anticlines and under the plains east of them may well be considerably less than 40,000 feet, but even so, it

is very great. The conditions, therefore, seem to be ideal for the generation of oil in great quantities—a thick sedimentary section containing bituminous marine shales, buried at great depths under younger rocks, and at two periods of its history (Late Paleozoic and Tertiary) subjected to mountain-building forces affecting only one side of the basin.

Everywhere northeast of the belt of Late Paleozoic orogeny indicated in Figure 1, the Devonian and later rocks escaped the strong regional metamorphism suffered by Paleozoic rocks south of that belt. In the region east of the Andes the Devonian and later sediments show no metamorphism. On the Andean plateau they may be slightly altered in places, but where the writer saw presumably Devonian rocks southeast of Oruro, on the divide northeast of La Paz on the road to the Yungas, and again west of Juliaca, Peru, they appeared to be entirely unmetamorphosed. It is said, however (Douglas, 1914, p. 46), that east of La Paz the Devonian shales locally show contact metamorphism around post-Devonian intrusives. Conditions may be different farther east, in the region between Cochabamba and Mizque, for Ahlfeld and Reyes (1939, p. 31) state that although asphalt showings are there found, all the older Paleozoic rocks show metamorphism. The Carboniferous rocks on the Altiplano, as well as along the eastern border of the Andes, are unmetamorphosed.

Under the conditions described in the preceding paragraphs, it is obvious that the Paleozoic sedimentary basin under discussion must have great oil possibilities. In view of the greater amount of tectonic disturbance and the reports of a certain amount of metamorphism in portions of that part of the basin that is now on the Andean plateau or Altiplano, it is convenient to consider that region separately.

OIL POSSIBILITIES ON ALTIPLANO

The Paleozoic rocks of the Andean plateau were folded at two epochs. One, in which the intensity of the folding probably was relatively mild in that part of the region lying in northern Bolivia and southern Peru, occurred in connection with the Late Paleozoic orogeny. The second occurred in the Tertiary, during the Andean orogeny. In places this folding was intense, but over considerable areas it was so mild that it is not believed to have destroyed the oil possibilities of the region. In fact, oil is actually present, as was proved by the discovery of the small Pirín oil field at the northern end of Lake Titicaca.

During a period of 10 years following the drilling, in 1905, of seven productive wells ranging in depth from about 300 feet to 820 feet, the Pirín field produced 265,000 barrels of good-quality oil (Jochamowits, 1939). In June, 1939, the Peruvian Departamento de Petróleo, in the course of further testing of the field, struck a "gusher," flowing initially 100 barrels per day of oil of 38.7° A.P.I. from a depth of 186 feet (Cabrera La Rosa, 1939).

The Pirín oil is found associated with a large, south-plunging anticline that exposes Devonian rocks in its core, overlain unconformably on parts of the anticline by calcareous beds of Lower Cretaceous age and, in other parts, by Middle Cretaceous which, in turn, is unconformable on the Lower Cretaceous.

The ten wells (of which seven were productive) drilled in 1905 were located along an important fault which cuts the anticline longitudinally, and the seepages at the surface are also associated with that fault. The reservoir rock in the wells seems to have been the Cretaceous, but, as Jochamowits states, it is difficult, on the basis of the present information, to determine the true source of the oil. By inference from the available descriptions, it seems probable that the source is Devonian, but the possibility remains that it is Mesozoic.

In either case, the Pirín field, though it has never yet been a commercial success, demonstrates that the high plateau of northern Bolivia and of Peru is potential oil territory. It should not be supposed that fields better than at Pirín may not be found on the Andean plateau. The structural conditions at Pirín do not seem to have been ideal, and much of the work was done without reference to geology.

In traversing by rail and auto more than 500 miles of the length of the Andean plateau in northern Bolivia and southern Peru and another shorter stretch in north-central Peru, the writer was struck by the openness of much of the folding and by the complete lack of metamorphism of the Mesozoic rocks and, apparently, of much of the upper Paleozoic section as well. Besides, oil-impregnated sands and seepages have been reported at several places on the plateau in Peru.

It seems more than probable that careful geological work on the Andean plateau and testing of the most favorable prospects will result in the discovery of commercial oil fields.

OIL POSSIBILITIES OF SUB-ANDEAN BELT AND OF PLAINS ON THE EAST

As is well known (Heald and Mather, 1922; Mather, 1922; Ahlfeld, 1939; Paiva, Reyes, and Mariaca, 1939), the sub-Andean belt, where the thick Paleozoic sediments already described are exposed along the base of the mountains, has many oil seepages and in it several oil fields have already been discovered. They have been opened on long anticlines lying in the belt east of the main Andes extending from near Santa Cruz, Bolivia, south into Argentina.

At least five fields, indicated by asterisks in Figure 8, have been discovered in Bolivia and an equal number in northern Argentina. All the latter are within less than 50 miles of the Bolivian border, for the favorable geological section and structural conditions seem to die out southward in Argentina as the axis of the Late Paleozoic orogeny (Fig. 1) is approached.

The oil is produced from various formations ranging from Devonian to Tertiary, but that found in the higher formations is believed to have migrated up from a lower source. Most of the oil is produced from sandstones lying either next above or next below a calcareous zone of supposed Jurassic-Cretaceous age, but the underlying Devonian is commonly thought to be the most probable ultimate source.

The oil possibilities of the region east of the Andes seem by no means to be restricted to the folds along the eastern front of the mountains, to which produc-

tion to date has been confined. The geological evidence points to the probability that the trough containing the thick Paleozoic sediments revealed in the Andes and along their entire eastern base must extend eastward under the plains of the Chaco of eastern Bolivia, western Paraguay, and northern Argentina.

The evidence favoring such an idea is strong, for about 70 miles east of the easternmost Andean fold, lying a short distance west of Santa Cruz, Bolivia, the Devonian rocks appear at the surface on the eastern side of the sub-Andean trough. Their outcrop extends thence southeasterly for more than 250 miles to within 70 miles of Paraná River before disappearing beneath the Quaternary alluvial deposits on the plains of the Gran Chaco, which effectively conceal all older rocks and structures.

This disposition of outcrops outlines a large sedimentary basin which we may call the Chaco basin, underlying the "Chaco" plains of Bolivia, Paraguay, and northern Argentina, having a north-south length along the eastern side of the belt of Andean folds of at least 650 miles; a width at the narrowest part, at the northern end, of about 70 miles; and a known maximum width of about 300 miles (Fig. 8). Along the western side of this basin, where gravity observations indicate it is deepest, the Devonian rocks must lie somewhere between 25,000 and 40,000 feet below the surface, and from the axis of the basin must rise toward the east at a rate of 100 to 400 feet per mile. Besides, as indicated by exposures on the eastern side of the basin, the Devonian section thins eastward, and, consequently, updip pinch-outs should be expected.

Exposures along the western side of the basin indicate that above the Devonian in the basin is a thick series of Permo-Carboniferous rocks (some of them presumably glacial) overlain by a considerable thickness of Triassic rocks of probably continental character, and these, in turn, by continental Tertiary sediments varying in thickness from more than 10,000 feet on the western side of the basin to perhaps less than 2,000 feet near Paraná River.

As previously suggested, the dominantly continental Tertiary section may hold in its midst a considerable thickness of marine Miocene or rocks of approximately that age, lying in a northward continuation of the Paraná trough shown in Figure 7.

Structures within the Chaco basin can not be worked from the surface, but in a recent publication (Rey and Oks, 1943), geophysicists of the Argentine Government oil company (Y.P.F.) have indicated the results of gravimetric and seismic studies in northern Argentina, including the provinces of Santa Fe, Santiago del Estero, Chaco, Formosa, and Salta. This work, while only in its initial stages, has yielded significant information on the conditions beneath the plains of the Chaco. The gravimetric studies show a pronounced "high," which may be called the Charata high after a town near its center, trending north-northeast through northwestern Santa Fe and central Chaco provinces (as indicated by the dashed line in Figure 8), from which the gravity values decrease markedly east, south,

and west, but most markedly and continuously toward the northwest to a decided "low" along the western side of the trough at approximately the position of the easternmost of the sub-Andean folds.

Seismic studies in the Chaco basin show pronounced structures with well defined dips below a persistent unconformity at the base of the gently dipping or nearly flat Tertiary formations that underlie the plain. The unconformity has been interpreted as the contact of the Tertiary sediments with the underlying rocks. As is shown by its depths at four points indicated by x-marks in Figure 8, the unconformity, in the area studied, dips northwestward toward the low point of the basin at an average rate of more than 20 feet per mile, the dip increasing progressively toward the west.

On the Charata high, seismic profiles of a local feature reveal beneath the unconformity (here found at about 2,600 feet) a regular anticlinal structure with $6\frac{1}{2}^{\circ}$ dips recorded to at least 8,000 feet. The profile indicates regularly bedded sedimentary rocks, but their age will not be known until the release of the results of a test well abandoned at 1,716.5 meters (5,631 feet) during the year 1944 (*Bol. Inf. Petroleras*, Vol. 21, No. 242, October, 1944, p. 37).⁸

As to the oil prospects of the Chaco basin: the nature of the geologic section, the depth of the trough, and the known presence of oil on its western margin justify confidence that the basin contains oil in quantity. On its west side, the presence of smaller folds east of the Aguaragüe anticline, the easternmost of the large folds, and the fact that in some of the present fields oil is found in the Tertiary rocks to which it has probably worked its way up from deeper beds, lead to the hope that oil accumulations within reach of the drill will be found along the western margin of the basin east of the present fields. But on account of the great thickness there of the rocks above the Devonian, and the sharp dip into the basin along its western side, the possibilities seem to be limited and the productive belt narrow.

It is in the eastern part of the basin where the Devonian and Permo-Carboniferous rocks are rising toward their outcrop that the great accumulations of oil seem most likely to be located. Dry holes on a feature like the Charata gravity high need not invalidate this expectation, for a structural feature of such size is very likely to be a buried mountain range like the Córdoba Hills or any other of the Pampean ranges, on the top of which the Devonian, and perhaps also the Permo-Carboniferous rocks would be missing. The oil accumulations would be more likely to be in pinch-outs or under unconformities on the flanks of such structures than on the tops.

Finding oil in the Chaco basin may not be easy, and the depths may be great,

⁸ Another deep test near Alhuampa (approx. $27^{\circ} 7\frac{1}{2}'$ S., $62^{\circ} 35'$ W.), about 90 miles to the west, went out of the Tertiary at 762.6 meters and, after traversing Mesozoic red-beds to 1,700 m., went into a series of gray clay shales, with intercalations of light quartz sandstones, in which the Permian Gondwana flora was found at 1,848-1,855 m. The test was abandoned at 2,101 m. (6,893 feet). (Gerth, 1935, p. 213.)

but oil should be there in quantity and the eastern and northeastern and the buried southern portions seem to hold the most promise.

SUB-ANDEAN TROUGH OF NORTHWESTERN
BOLIVIA AND SOUTHEASTERN PERU

A map of the sub-Andean trough of northwestern Bolivia and of Peru and Ecuador is shown in Figure 10.

Northwestward from the great bend in the Andean front near Santa Cruz, Bolivia, strong seepages and other indications of oil are found along the Andean front at many places, particularly in a region east of Cochabamba and in another extensive region near the Peruvian boundary where foreland folds seem to be well developed (Ahlfeld, 1939, pp. 28-30). In spite of its many seepages, this region has not been thoroughly explored or tested, on account of dense forest cover, very wet and unhealthy climate, difficulty of access, and consequent high cost of operations.

Since this region lies at the eastern foot of the Andes directly northeast of Lake Titicaca, where the Devonian section is well developed, it is probable that the favorable Devonian section found farther south along the mountain front is present here also. But approximately 350 miles northwest, in Peru (12° to 13° S., 73° W.), Bowman (1916, pp. 233-247), in his survey of the 73d meridian, found Carboniferous rocks resting directly on what were believed to be Silurian, with no Devonian present.

In that region, where the Urubamba River breaks through the mountain front, Bowman (*op. cit.*, p. 241) found what he estimated to be more than 10,000 feet of Carboniferous rocks, mainly limestone, resting unconformably on slates of probable Silurian age, in fault contact with the Tertiary sands and gravels of the sub-Andean trough.

Concerning the geology and structure of the sub-Andean belt in southeastern Peru, little geological information has been found, but the presence on Steinmann's map (Steinmann, 1929) of patches of Carboniferous along Río Manu (*ca.* $11^{\circ} 50'$ S., $71^{\circ} 20'$ W.) and elsewhere at considerable distances east of the Andean front suggests the presence of outlying folds.

The sub-Andean sedimentary trough of northern Bolivia and southeastern Peru, in the section under discussion extending from Santa Cruz, Bolivia, to the point where Río Tambo breaks through the mountains (*ca.* 11° S., 74° W.), has a length of about 860 miles and an unknown width varying from a minimum of about 70 miles near Santa Cruz to 300 miles or more in southeastern Peru and adjacent parts of Acre Territory, Brazil. Little is known of the sediments that may underlie the trough. A mantle of Late Tertiary and Quaternary sands, clays, and gravels obscures the older rocks. Devonian and Carboniferous rocks are known to be present in favorable facies in the Bolivian part of the trough. The Devonian presumably is absent in the northwestern part, in Peru. In that region the enormously thick Carboniferous limestones exposed in the mountains on the

west must extend eastward into the trough, but at what depth they may lie and what facies changes they may undergo, we have no knowledge. Evidence in the Andes, as interpreted by Bowman, indicates that the source of the Carboniferous clastic sediments lay at the west, and the open sea at the east, but no Carboniferous is shown on the Geological Map of Brazil (de Oliveira and Leonardos, *Geologia do Brasil*) east of the sub-Andean Tertiary in this region. The limestones exposed at the mountain front must, therefore, either pinch out not far eastward under the trough or they must have been beveled by pre-Tertiary erosion.

Presumably, also, the marine Jurassic and Cretaceous rocks, well developed on the Andean plateau on the west, extended for some distance east of the present mountain front and would be expected to exhibit shore-type facies and pinch-outs along their eastern margins, though it is possible that these, too, may have been beveled, at least in part, by erosion.

We thus have reason to expect that in the sub-Andean trough of southeastern Peru and in adjoining parts of Brazil and northern Bolivia, sediments may exist ranging in age all the way from Devonian to Cretaceous, that would be favorable for the generation of oil, but except close along the mountain front and on the east, where they lap onto the Brazilian shield, they are likely to be very deep and to be discoverable only by geophysical means, though it is possible that aerial photography may reveal more structure in the region than has been suspected. Inaccessibility, dense forest cover, and a wet and unhealthy climate are unfavorable to early development of the region.

SUB-ANDEAN TROUGH IN NORTHERN PERU AND ECUADOR⁹

Along the eastern border of the Andes northwest from the Tambo River gap, foreland folds are moderately well developed. The anticlines bring to the surface rocks of Lower Cretaceous age and reveal a Cretaceous geological section offering great promise for oil generation and accumulation (Singewald, 1927, 1928; Moran and Fyfe, 1933; Chase, 1933). These rocks have been proved productive in the first anticline to be adequately tested.

The Cretaceous section is probably best exposed at Pongo de Manseriche (4° 25' S., 77° 36' W.) where the Marañón River breaks through the easternmost of the foreland folds. As measured by Singewald (1927) the section there begins with the "Pongo sandstone" of Lower Cretaceous or in part possibly Upper Jurassic age, of which 1,000 feet are exposed without the bottom being visible. This is overlain by the "Shale-limestone series" of Middle Cretaceous age, consisting of about 3,500 feet of calcareous shale and limestone, together with thin beds of sandstone aggregating perhaps 100 to 300 feet. The most pronounced of these sandstones, called the "Huacanqui sandstone," lies near the top of the series. Above the Shale-limestone series are 8,000 feet or more of "red beds" consisting of sandstone and sandy shale, calcareous shale, and clay shale. (In other localities, farther south, this formation contains also salt and gypsum.) In their lower part the red-beds are believed to be Upper Cretaceous, and in their upper

⁹ Figure 10.

part early Tertiary. Above them are younger, but pre-Pliocene, Tertiary clays and sandstones whose thickness exceeds 1,000 feet by an unknown amount.

Explorations all along the mountain front from Pongo de Manseriche southwest to the Tambo River gap, and even east of the front, in Acre Territory of Brazil, reveal essentially the same type of Cretaceous section, and oil seepages are found at many places.

On one of the easternmost foreland folds in the southeastern part of the section of the sub-Andean trough under discussion, Peru's first oil field east of the Andes, the Agua Caliente field, has been developed within the past 6 years. It is located near the junction of the Pachitea and Ucayali rivers, as nearly as can be determined from conflicting accounts, at approximately $8^{\circ} 37' \text{ S.}$, $74^{\circ} 35' \text{ W.}$ The field is on the top of a broad dome (Fig. 11), not far from Ucayali River, and its oil comes from Lower Cretaceous rocks at a depth of about 1,100 feet (Greene, 1939).

The photograph of the Agua Caliente dome is introduced primarily to illustrate a fact that will be of the greatest importance in the exploration of the sub-Andean trough all the way from central Bolivia to central Colombia, namely, that wherever geological structure is expressed in topography, even though of moderate relief, it can be seen and photographed from the air. This is true even where the surface is covered by a dense equatorial rainforest with trees more than 100 feet high.

The photograph shows also that wherever alluvium is absent and bed-rock is being eroded, it may be possible to determine the pattern of the rock outcrops by vegetation alone, irrespective of relief. This possibility is well illustrated in Figure 11, where the central "turtle-back" of the dome is marked by forest of exceptionally dark shade; a surrounding belt of weaker rocks by lighter-colored trees; and the rim-rock by a distinct band of dark forest.

Modern methods of photogrammetry will make possible relatively exact location, on a map, of any promising structures that may be discovered from the air.

To return to the ground: the Cretaceous rocks may not be the only ones in the trough having oil possibilities, for on the high plateau of the Andes only a comparatively few miles farther west—in the Cerro de Pasco region, for example—Jurassic limestones more than 4,000 feet thick are exposed (McLaughlin, 1924), and there is every reason to expect that they should extend eastward under the sub-Andean trough. Somewhere under the trough they should be expected to wedge out or to be beveled and overlain by younger rocks as the eastern margin of the trough is approached. In the southeastern part of the area under discussion, the thick Carboniferous limestones cropping out at the Urubamba gap are also probably present under the trough. They may be absent in the northern part of the area, for in the Cerro de Pasco region Carboniferous rocks are only moderately developed.

Paleogeographic evidence indicates that during the Cretaceous the sediments of the present sub-Andean trough were being deposited on the eastern flank of a geosyncline lying between the Brazilian shield and highlands located somewhere west of the present Andes. What is believed to be the equivalent of the Pongo

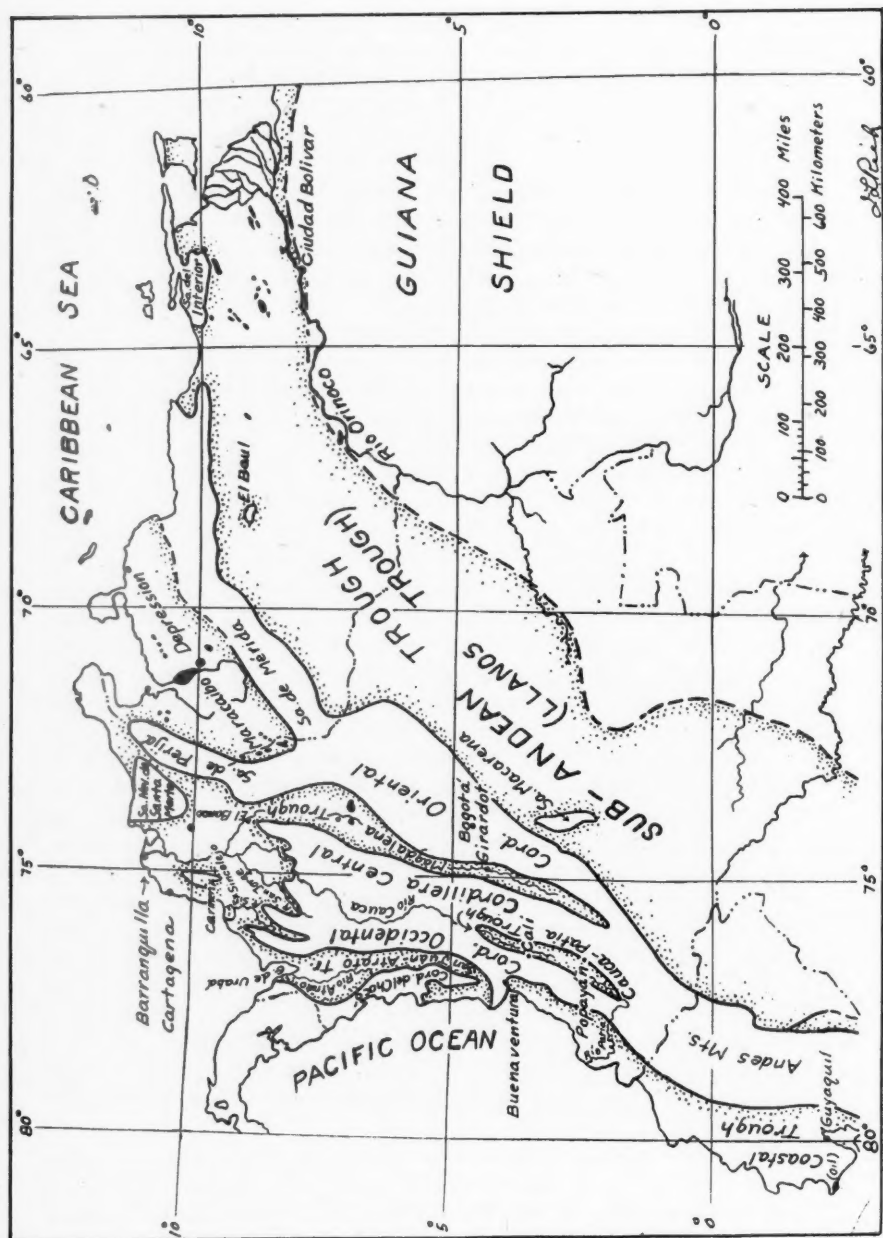


FIG. 12.—Llanos trough and intermont basins of Colombia and Venezuela.

sandstone of the eastern slope thickens and becomes coarser westward (Cerro de Pasco region) and contains intercalations of shale and beds of coal. This indicates a condition similar to that found in the western part of the Cretaceous Rocky Mountain geosyncline, where marine Cretaceous rocks interfinger westward with sandy, coal-bearing beds.

Somewhere east of its exposure at Pongo de Manseriche and in the other anticlines along the Andean front, the Pongo sandstone and the sandstones of the "Red beds" series above it must wedge out eastward as they approach the margin of the trough along the western border of the Brazilian shield.

It is in this eastern part of the trough that the writer conceives the most attractive oil possibilities to lie—along the updip-wedging edges of sediments rising relatively steeply eastward out of the sub-Andean trough.

At Pongo de Manseriche the estimated thickness of sediments above the Pongo sandstone is at least 13,500 feet, and we do not know but that a considerable additional thickness of Jurassic rocks may lie beneath the Pongo sandstone. From the bottom of the sub-Andean trough, which probably lies not far from the mountain front, the rocks must, therefore, rise eastward at a relatively rapid rate. This gives extremely favorable conditions for the eastward migration of oil out of the deeper western parts of the trough and its accumulation in wedge pinch-outs or in any structures that may be in its eastern part.

Conditions similar to those described in the preceding paragraphs continue northward along the Andean front through Ecuador and into Colombia, but there the foreland folds are probably less developed.

Little has been written on the geology of the sub-Andean belt in Ecuador, except a paper by Wasson and Sinclair (1927) on an area near Napo extending along the front from $0^{\circ} 30' S.$ to $2^{\circ} 30' S.$ They found a Cretaceous section similar to that at Pongo de Manseriche except that the thicknesses of the various members are considerably less. In the area visited they found the base of the main Andean range to be marked by a great fault and that as the mountains are approached, the rocks of the plains reverse their normal eastward inclination and dip westward for a short distance into the fault, forming anticlinal structures. Abundant evidences of oil were noted.

A large concession in eastern Ecuador is now (1944) being tested by a well located approximately 30 miles east of Napo (*Petróleo Interamericano*, Vol. 2, November–December, 1944, pp. 139, 140, 143).

SUB-ANDEAN OR LLANOS TROUGH OF COLOMBIA AND VENEZUELA

In a broad way, conditions under the Llanos of Colombia and Venezuela are similar to those described for eastern Peru and Ecuador. A deep geosynclinal trough paralleling the eastern front of the Andes is bordered on the west by the mountains, and on the east, about 300 miles away, by the crystalline rocks of the Guiana shield (Fig. 12). This trough, however, is divided into three subsidiary basins by two horst-like uplifts of the underlying basement rocks. One comprises

the Cordillera Macarena and its presumed continuation southeast across the trough to the Guiana shield. The other is shown at the surface by a projecting outlier of older crystalline rocks at El Baúl in central Venezuela. South of the Macarena uplift is the basin of southern Colombia, Ecuador, and northern Peru; between the Macarena uplift and El Baúl is the Llanos basin of northern Colombia and western Venezuela; and east of El Baúl is the Llanos basin of eastern Venezuela.

In general, the rocks of the Llanos trough comprise a great thickness of Cretaceous and Tertiary sediments which, in the lower (Cretaceous) part are dominantly marine, but in the upper (Tertiary) part are probably mainly continental in Colombia but grade into dominantly marine in eastern Venezuela. As a rule, the trough is believed to be deepest on its west and north sides, close to the mountains. The various components of its sedimentary filling may be presumed to thin not far away from the Andes toward the crystalline rocks of the Guiana shield.

LLANOS OF COLOMBIA

In Colombia the rocks of the Llanos trough have not yet been explored by drilling, but exposures in the Eastern Cordillera of the Andes (Cordillera Oriental) and in folds and faulted blocks along the eastern base of these mountains indicate what may be expected under the western portion of the Llanos.

In the Eastern Cordillera various Paleozoic rocks, including marine Devonian, underlie the Cretaceous sediments. Some of these have been metamorphosed so highly that they have no oil possibilities. Others, like the Devonian rocks at Floresta (Caster, 1942), are not noticeably metamorphosed. Whether the metamorphism is confined to the mountain region is, of course, unknown, but whether metamorphosed or not, the Paleozoic rocks of the western Llanos would be so deep as to be of little interest to the petroleum geologist. However, along the east side of the trough it is entirely possible that Paleozoic rocks in unmetamorphosed facies may lie within reach of the drill as they lap onto the older rocks of the Guiana shield.

The Cretaceous section exposed in the Eastern Cordillera appears highly favorable for petroleum. It contains not only a thick section of dark shales of high organic content, the Villeta formation, that may be expected to have generated oil, but also, above the shales, it contains massive beds of porous sandstone, the Guadalupe formation, capable of constituting a suitable carrier bed for oil migration and reservoirs for its accumulation.

The Villeta formation, with a thickness ranging up to several thousand feet, consists mainly of dark, marine shale of which a considerable part is so bituminous as to constitute true oil shale. In the upper Magdalena valley and along the eastern front of the Andes of southern Colombia, oil seepages, oil-stained sandstones and asphaltic fissure-fillings are recorded from a large proportion of the places where the Villeta shales appear in outcrop.

The Guadalupe formation, overlying the Villeta, consists of relatively clean, well bedded marine sandstone ranging in thickness up to 1,000 feet or more.

Above the Guadalupe comes a dominantly continental series of coal-bearing sandstones, shales, and conglomerates, called the Guaduas formation, whose age in various parts of Colombia seems to range from Eocene, or possibly uppermost Cretaceous, to Oligocene. In northern Colombia the equivalent of the Guaduas formation seems to grade northward, by interfingering, into marine deposits.

Above the Guaduas in the western Llanos comes a great thickness of Miocene and later Tertiary and Quaternary rocks formed by the accumulation, in a sinking geosyncline, of the products of the erosion of the Andes mountain range that

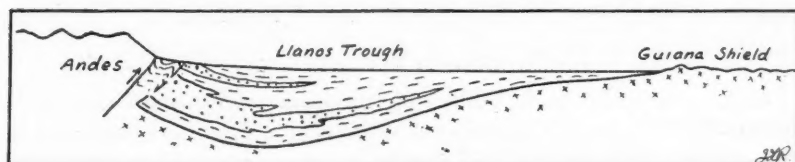


FIG. 13.—Diagrammatic sketch to illustrate probable conditions under Llanos trough, with sandy sediments rising and pinching out eastward from axis of trough.

was then rising parallel with and adjacent to the syncline. These later Tertiary rocks, in Colombia, are believed to be mainly continental.

Estimates vary as to the thickness of the Tertiary rocks under the Llanos of Colombia. The thickness certainly is several thousand feet, and in places may be 12,000 feet or more.

In so far as they were derived from the erosion of the present Eastern Cordillera or of an older landmass farther west, the sediments of the Llanos trough may be expected not only to thin, but also to become finer in texture, and wedge out eastward. If, as is supposed, the deepest part of the trough is close to the mountain base, these wedging sediments, under all but the western portion of the trough, will be rising at a considerable angle eastward toward the Guiana shield, especially in the lower and deeper part of the section (Fig. 13). Here, as in the region farther south along the sub-Andean depression, the conditions in the eastern two-thirds of the trough should be highly favorable for the accumulation, in sedimentary wedge pinch-outs, of oil generated in the deeper western third of the trough. Early drilling is likely to be confined to the western margin of the trough because there the section is best known and tectonic structures can be found, but in the writer's opinion, the greater part of the oil of the region is likely eventually to be found under the eastern two-thirds of the trough rather than under the first-to-be-tested western part. Another factor that will contribute to such a result is that, in so far as overthrusting has not covered the outcrops of the porous members of the section along the mountain front and protected them from the

intake of artesian water, *flushing* by water is likely to have an unfavorable effect on the oil possibilities of structures close to the mountain front.

In connection with oil possibilities in sedimentary wedges along the eastern side of the Llanos trough, a problem of the greatest importance is the source of the sand that formed the Upper Cretaceous Guadalupe sandstone. If that sand came from the west or even was derived from some of the earliest of the Andean uplifts, it should be expected to thin and wedge out under the Llanos and its wedging edge should constitute one of the most attractive oil possibilities that could be imagined. If, on the other hand, the source of the sand was in the Guiana shield, as has been suggested by Oppenheim (1942, p. 245), the Guadalupe sandstone would probably thicken and coarsen eastward, so that favorable wedge traps for oil under the eastern Llanos would be much less likely.

LLANOS OF VENEZUELA

Both topographically and geologically the Llanos of Venezuela are a direct continuation of those of Colombia but their trend is dominantly east-west instead of northeast-southwest as in Colombia.

The protruding mass of ancient crystalline rocks at El Baúl is believed to divide the Llanos trough in Venezuela into a western and an eastern section, but the geological relations of the El Baúl uplift are little known and one can not now say with confidence how complete that separation may be.

The geological conditions in the western section of the basin have not yet been tested by drilling, and no results of geophysical work in the area have come to the writer's attention. It is presumed, however, as was stated in the discussion of the Colombian Llanos, that the trough between El Baúl and the Cordillera Macarena is very deep and contains a thick filling of Mesozoic and Tertiary sediments. Something of the nature of these sediments can be determined from exposures along the northwestern border of the trough where, for much of a distance of about 250 miles along the southeast flank of the Venezuelan Andes (Sierra de Mérida), Cretaceous and Tertiary rocks dip beneath the Llanos (Engleman, 1935). The Cretaceous rocks in this section are such as might be expected to produce oil and, in fact, they show oil seepages at several places. The Tertiary rocks, however, appear to be mainly continental.

East of El Baúl conditions are different from those in Colombia and western Venezuela in that the sea entered the trough from the east during various stages of the Tertiary, especially in middle and late Tertiary, so that marine Tertiary as well as Cretaceous rocks contribute to the oil possibilities of the region.

The geological history of the eastern Venezuelan trough has been essentially as follows (Hedberg, 1937; Hedberg and Pyre, 1944): during the Cretaceous and Tertiary periods a mountainous landmass, called Paria, lay at the north, in a region which now is mostly sunken beneath the Caribbean Sea. South of Paria, and trending parallel with it, lay a sinking geosynclinal trough which, by filling, has become the Llanos and the Orinoco Delta plain of eastern Venezuela.

At intervals from the early Cretaceous to the Pliocene the actively growing

mountain belt of Paria suffered renewed orogenic activity and pushed farther southward, crumpling and uplifting the sediments along the northern border of the geosyncline, shifting the axis of the trough each time a little farther southward, and permitting erosion to bevel the newly upturned beds at the north before they were covered unconformably by sediments laid down in the next succeeding period of quiescence:

The result of several repetitions of the process described was that in the axial part of the geosyncline deposition was essentially continuous, much of it marine but some of it continental; at the north the sediments were repeatedly crumpled and beveled, so that strong angular unconformities are present; while along the southern side of the trough, on account of the progressive southward migration of the axis of subsidence, the younger formations overlap the older, but all formations are essentially parallel, with only occasional hiatuses instead of angular unconformities such as are found along the northern side of the trough.

The island of Trinidad lies in an eastern continuation of the geosynclinal trough of eastern Venezuela, and had an essentially similar geological history. The island, however, comprises only a part of the northern portion of the trough.

On account of the presence during most of late Mesozoic and Tertiary time of a growing mountain range north of the east Venezuelan geosyncline, which shed enormous amounts of sediment into the northern part of the trough, the geological section in the trough can not be very satisfactorily generalized because of great and rapid facies changes from north to south and from west to east. The deposits made during a given time-interval are generally much thicker and coarser in the northern part of the basin than in the southern and are less likely to be marine in the western than in the eastern part.

A section measured in northern Anzoátegui in and near the southwestern flank of the Serranía del Interior (Hedberg and Pyre, 1944) shows about 5,000 feet of Lower Cretaceous shallow-water sandstones, shales, and reef limestones followed by a deeper-water facies of Upper Cretaceous age consisting of 3,000 to 4,000 feet of black carbonaceous-bituminous limestone and calcareous shale with local developments of sandstone and chert in its upper part. Overlying this is a series of about 2,400 feet of sandstone, shale, and calcareous and dolomitic siltstones and glauconitic sandstones, the Santa Anita formation, of latest Cretaceous-early Eocene age. This is followed by 5,500 to 7,500 feet of late Eocene to early Oligocene rocks, the Merecure formation, that are marine in the lower part and coal-bearing in the upper part. These coal-bearing beds grade upward into about 24,000 feet of sandstones, grits, conglomerates, shales, and claystones of middle Oligocene to late Miocene age called the Santa Inés formation. This formation becomes progressively more marine from west to east and includes a deep-water foraminiferal shale member, the Carapita shale. Overlying the Santa Inés with a great unconformity is a non-marine Pliocene section that, locally, is several thousand feet thick. Along the northern side of the trough this overlaps on folded and eroded Miocene rocks.

The foregoing section may be expected to thin within a short distance south-

ward, particularly in the post-Eocene part. An indication of this rapid thinning is the fact that in the oil fields of the San Joaquin district, about 40 miles south of where the section was measured by Hedberg and Pyre, oil wells are drilled entirely through the Oligocene-Miocene Santa Inés formation into the Eocene-Oligocene Merecure formation at depths between 9,000 and 10,000 feet. It may be, however, that they start considerably below the top of the Santa Inés and that, therefore, the southward thinning is considerably less than the difference between 24,000 and 10,000 feet.

The eastern section of the Llanos trough of Venezuela is being proved to be richly petroliferous. The oil is being found rather widely distributed over the trough from close to the base of the Serranía del Interior (Quiriquiri field) to within 30 miles of the Orinoco River at the southern border of the trough (Temblador field). In most of the fields the oil is found in rocks of Oligocene-Miocene age, but it is probable that potentially petroliferous older Tertiary rocks lie below. But in the fields of the southern half of the trough the oil is found in these Oligocene-Miocene beds where they lie unconformably on the Cretaceous (González de Juana, 1944).

Five fields forming the San Joaquin group, in the central part of the state of Anzoátegui near the center of the trough, are producing from the Oligocene-Miocene sands at depths of more than 9,000 feet. In these fields several wells, drilled deeper, have found important flows of gas condensate in the underlying Eocene rocks.

It seems evident that the eastern Llanos trough will eventually yield a very important share of the oil production of Venezuela.

INTERMONT BASINS AND TROUGHS OF WESTERN VENEZUELA AND OF COLOMBIA

On account of the branching of the Andes and the consequent widening of the Andean belt in northern South America, no less than five intermont basins or troughs have been formed. In each of them thick series of Mesozoic or Tertiary-to-Recent sedimentary rocks have been deposited, and each either is producing oil or has more or less favorable prospects of doing so.

These basins are: the Maracaibo basin and adjoining parts of the states of Falcón and Lara in Venezuela, the lowlands of northern Colombia, the Magdalena trough, the Cauca-Patía trough, and the Atrato-San Juan lowland.

In addition, a lowland along the Pacific coast extending from Buenaventura, Colombia, southward into Ecuador, though little known geologically, has been found to be underlain by sedimentary rocks that may be productive of oil as have those of the continuation of this belt into Ecuador and Peru.

MARACAIBO DEPRESSION

At their extreme northeast end, the Andes split into two diverging mountain ranges, the Sierra de Perijá, trending a little east of north, on the west, and the

Sierra Mérida, trending northeast, on the east. The large structural depression included within the angle made by the divergence of the two ranges, and bounded on the north by the Gulf of Venezuela and the Caribbean, is here designated as the Greater Maracaibo depression. It consists of two quite distinct regions: at the southwest is the Maracaibo basin proper, a topographical as well as a structural basin comprising the low plains including and surrounding Lake Maracaibo; at the northeast is a hilly region extending from the Maracaibo basin proper northeast to the Caribbean Sea and including all of the State of Falcón and most of that of Lara. Differences in the post-Miocene history of these two parts have made the former one of the world's most important oil reserves and the latter a region whose oil possibilities are comparatively small.

The Greater Maracaibo depression, that is, both of the subdivisions previously mentioned, taken together, has a length of about 325 miles and a width of about 130 miles. The Maracaibo basin proper is about 180 miles long and 130 miles wide.

Previous to the uplift of the two bordering mountain ranges, the region was part of a larger geosynclinal area covering much of Venezuela and adjacent parts of Colombia. Over this larger area, a thick section of Cretaceous marine sediments containing highly bituminous members (Hedberg, 1931) is followed conformably by a considerable thickness of Eocene sediments, some of which are marine and notably organic in nature.

Beginning probably in the late Eocene or early Oligocene, the Perijá and Mérida ranges began to be uplifted, and the Greater Maracaibo depression was outlined. Within this newly outlined depression deposition continued, and many thousand feet of Oligocene and later Tertiary sediments were deposited. These, also, were in considerable part marine and rich in organic material. The sedimentary record of post-Eocene time was not simple, for the region was subjected to repeated irregular and local elevations and depressions and at times seems to have been an archipelago (González de Juana, 1938; Wiedenmayer, 1937).

It does not seem entirely clear from available descriptions whether conditions of deposition during the Oligocene and Miocene were similar in both parts of the Maracaibo depression, for there are some indications that during that period some of the local uplifts that caused unconformities in the Falcón-Lara section of the depression did not affect the Maracaibo basin proper. It is clear, however, that during and after the active orogeny of the late Miocene and Pliocene periods the two parts of the region were affected differently. The northeastern part, in Falcón and Lara was not only folded, but was uplifted and eroded; while the southwestern part, the Maracaibo basin proper, was depressed, so that the richly petroliferous geological section, ranging in age from Cretaceous through Miocene, was covered and preserved instead of being uplifted and eroded as it was in Falcón and Lara.

Folding in the Maracaibo basin proper was, however, sufficient to form numerous traps for oil which are now being actively exploited, not only in the Vene-

zuelan part of the basin but also in its extreme southwestern part—the Barco Concession—in Colombia (Aguerrevere, 1942).

Several oil fields have been found in Falcón, but with much of the petroliferous part of the section eroded and with regional metamorphism affecting the eastern part of the area in Lara, the prospects of this half of the depression are only moderately favorable.

LOWLANDS OF NORTHERN COLOMBIA

The lowlands of northern Colombia cover a large, roughly rectangular area about 300 miles long from southwest to northeast and 140 miles wide. The lowland is bordered on the east by the northern extension of the Cordillera Oriental (Eastern Cordillera), here called the Sierra Perijá; on the north by the high, block-like mountain mass of the Sierra Nevada de Santa Marta; on the west by the Caribbean Sea; and on the south by the frayed northern ends of the Cordillera Occidental and the Cordillera Central which, in numerous sprawling spurs, plunge beneath the northern lowlands. It comprises the lower valley of the Magdalena River below the great westward bend at El Banco; the valley of Río Cesar, which enters the Magdalena from the north near El Banco and drains that part of the lowland lying between the Sierra Perijá and the Sierra Nevada de Santa Marta; the lower valleys of the Cauca River and of Río San Jorge which enter the Magdalena from the south; the valley of Río Sinú which rises in the mountainous part of the Cordillera Occidental and, flowing northward between the sprawling spurs of that range empties directly into the Caribbean; and a strip about 20 miles wide along the Caribbean coast that drains directly into the sea.

A large area in the central part of the northern lowlands is a swamp that seems to be sinking and in process of alluviation by the Magdalena, Cesar, Cauca, and San Jorge rivers. Over this area the streams divide and flow in an intricately branching pattern. This swampy area comprises the land bordering the course of the Magdalena for about 70 miles below El Banco and the lower courses of the other rivers mentioned.

The lowlands of northern Colombia are underlain by thick Tertiary and Quaternary formations ranging in age from Eocene to Recent. The Tertiary beds are dominantly marine in the north and partly brackish-water or continental in the southern part of the lowlands.

The Early Tertiary beds, of probable Eocene age, are well exposed along the southern border of the lowlands and in one or more anticlines which form a belt of hills extending north-northeast toward Barranquilla from between the valleys of Río San Jorge and Río Sinú. Along the southern side of the lowlands, Early Tertiary coal-bearing rocks of continental type interfinger with the marine rocks that make up the bulk of the series farther north.

Anderson (1926, 1928) states that the Eocene strata around El Carmen are at least 4,500 feet thick. Between proved Eocene and the base of the fossiliferous Miocene is a series from 500 to as much as 3,400 feet thick which is thought to be

Oligocene in age. It consists of sandstones, sandy shales, shales, and a few conglomerates (Anderson, 1929). Like the Eocene strata below them, these Oligocene (?) strata are highly organic and commonly have oil and gas seepages along their outcrops and along faults which cut them.

The afore-mentioned Eocene and Oligocene rocks are believed to underlie most, if not all, of the northern lowlands, though away from the margins of the basin they are overlain by great thicknesses of younger rocks.

Overlying the proved Eocene and probable Oligocene rocks, lies a thick series of shales and sandstones with a few thin beds of limestone, having an aggregate thickness of 5,000 feet or more, that has been determined as Miocene (Anderson, 1929). The Miocene rocks under the northern lowlands are dominantly if not entirely marine, but are not reported as being highly organic like the Eocene and Oligocene (?) rocks below them.

The structure of the northern lowlands is complex, at least along the western side. Here it appears that the structural deformations responsible for the Cordillera Occidental continue unabated toward the north-northeast and have involved the Tertiary rocks of the lowland. Since those rocks are relatively soft, erosion has tended to keep pace with uplift so that there high mountains have not been formed. One large anticline in this belt extends north-northeast for more than 50 miles through the vicinities of Sincelejo and El Carmen (Beck, 1921; Anderson, 1926). In this western part of the lowlands, folding is sharp and in places very complex. Large-scale faulting has been recognized.

Not much seems to have been published about the structure of other parts of the northern lowlands but it is known that considerable folding and faulting exist.

The northern lowlands, especially their western part, have seen considerable testing for oil extending over many years. Showings of oil and gas were found in many of the tests, but until May, 1943, no attractive commercial production had been found. Most of the wells were drilled near seepages, many without competent geological advice, and in regions where the structure is complex. Petroleum companies are now exploring the region and several deep tests have been drilled recently, resulting, to date, in one new field at El Difícil on the plains east of the lower Magdalena River not far from the southwestern corner of the Santa Marta Mountain mass.

In summary: the lowlands of northern Colombia comprise an area of about 40,000 square miles underlain by a thick series of dominantly marine Tertiary rocks whose lower members are highly bituminous. The entire region is reported to have been more or less folded and faulted, and oil and gas seepages are numerous. In some parts, particularly in the western third of the lowland, the folding and faulting have been intense. On the whole, however, the lowland does not seem to have been so much broken as to diminish seriously the probability that important oil fields will ultimately be found there. The region therefore seems to this writer to offer decidedly favorable prospects for oil discovery.

Exploration has been and will continue to be hampered by a blanket of relatively recent sediments that covers a considerable part of the surface and forces the use of geophysical methods for determining structure. Surface geological work is also hindered by the prevailing deep weathering of the rocks and, in parts of the area, by swamps, forests, and jungles.

On the accompanying map (Fig. 12), the lowlands of northern Colombia are placed in the highest of the three ranks used to indicate relative oil possibilities.

MAGDALENA TROUGH

The Magdalena trough is a graben-like depression extending south from the vicinity of El Banco between the central and the eastern ranges of the Andes, the Cordillera Central and the Cordillera Oriental. Its total length is about 450 miles and its width varies from an average of about 50 miles for the northern half to about 30 miles for the southern. The northern half of the trough has a low, relatively flat floor about 50 miles wide between the 200-meter contours on either side. The bottom of the southern half of the trough, south of $5^{\circ} 30' N.$, is rougher and its surface is broken by numerous short ranges due mainly to faulting.

The Magdalena trough as a whole is underlain by sedimentary rocks ranging in age from early Mesozoic to and including Quaternary. Rocks of pre-Middle Cretaceous age (the Jiron series et cetera) which probably underlie much of the trough may be omitted from this discussion because their composition is such as to make them unattractive from the point of view of the petroleum geologist.

A generalized section, beginning with the Cretaceous, shows at the base a great body of dark-colored and rather highly bituminous marine shales and thin limestones, the Villeta formation, 2,000 to 6,000 or more feet in thickness. The Villeta formation is generally considered to be a particularly promising source rock for oil.

Above the Villeta shale lies the Guadalupe formation, also marine, composed mainly of clean, rather even-grained quartz sandstone together with beds of siliceous shale. The thickness of the formation, as reported, varies from a few hundred to more than 2,000 feet. A great cliff of this sandstone, showing a thickness of a thousand feet or more, forms the western crest of the Eastern Cordillera in the region between Girardot and Bogotá.

Resting with at least local unconformity on the Guadalupe is the Guaduas formation, of probable Eocene age, whose thickness reaches at least 6,500 feet. This is the coal-bearing formation of Colombia. In the northern part of the Magdalena trough the rocks of the Guaduas (there called the La Paz) formation are estuarine and in part marine, and are reported to be highly organic and bituminous. In the southern half of the trough they are believed to be entirely continental.

Unconformably overlying the Guaduas formation comes a thick series of sandstones, sandy shales, shales, and conglomerates of probable Miocene age called the Barzalosa formation. The thickness of these rocks apparently varies

greatly but ranges between 3,000 and 7,000 feet. The Miocene rocks in the northern part of the trough are at least partly of brackish-water or marine origin and are bituminous in character. In the southern part of the trough they are thought to be entirely continental (Anderson, 1927).

Unconformably overlying the Miocene beds in the trough, which, in general, have been rather severely folded and faulted, are about 1,000 feet of rocks, called the Honda formation, that have been comparatively little disturbed since their deposition and still in most places lie approximately horizontal. The Honda formation is composed largely of volcanic tuff and ash with interbedded river gravels. It is believed to be Pliocene in age. It marks the earliest appearance of abundant volcanic débris.

Quaternary fan gravels and river alluvium mantle considerable parts of the bottom of the Magdalena trough.

STRUCTURE

The Magdalena trough as a whole appears to be a graben bordered for most, if not all, of its extent on both east and west sides by faults, most of which have been described as being overthrust toward the trough.

The rocks in the bottom of the trough have been compressed and rather complexly folded and faulted (Figs. 14, 15). In the wider northern portion, well developed folds have been found, but in the southern half the available descriptions indicate that faulting has been dominant, with folding only incidental to the faulting. That part of the trough bottom seems to be a complex mosaic of small fault blocks.

OIL POSSIBILITIES

Oil seepages and asphalt-impregnated sands have been found at numerous places in the Magdalena trough, both in the wider northern half and in the southern.

In the northern part of the trough, between Lats. 7° and $7^{\circ} 20' N.$, oil is now being produced from four important fields, of which two are comparatively recent discoveries while the others have been producing since 1921. The oil in these fields is found in Tertiary rocks (Eocene and Oligocene) at no less than three horizons. The largest and oldest field, Las Infantas, has produced most of the oil obtained from Colombia until recently, when the fields in the Barco Concession also began to supply oil in quantity.

Geologists who have studied the petroleum geology of Colombia have disagreed as to the probable source of the oil in the fields of the Magdalena trough. Most, perhaps, have thought of the dark-colored, commonly bituminous, Cretaceous Villeta shale as being the probable source of the oil, but others think that the more likely source is in the Early Tertiary rocks which form part, at least, of the reservoir rocks of the producing pools and whose correlatives in northern Colombia are highly bituminous.

In the southern half of the trough oil seepages prove the presence of oil in the region but no successful oil wells have yet been drilled. The rather intense block faulting in that region will probably make it difficult to find favorable traps for oil accumulation, and an extensive cover of latest Tertiary and Quaternary gravels that mantles much of the lower land of the trough will interfere with the detailed surface geological work which will be required to locate any oil that may be present.

Because it already has important oil fields and because of its generally favorable geological conditions, the northern half of the Magdalena trough is classed with the most promising prospective oil regions of South America; the southern half, because of rather unfavorable structural conditions, is placed in the "possible" class.

CAUCA-PATÍA TROUGH

The Cauca-Patía trough is a long, narrow depression trending about N. 22° E. between the Western Cordillera and the Central Cordillera of the Andes. It has a width of 10 to 30 miles and a length of about 250 miles, extending from 1° 20' to 4° 40' North Latitude. The northern two-thirds of the trough, drained by the Cauca River, is divided from the southern third drained by the Patía River, by a gravel-mantled remnant of a former higher trough bottom which, in the latitude of Popayán, extends from side to side of the depression and forms the divide between the two streams.

STRUCTURE

The Cauca-Patía trough, though definitely a graben, apparently is not one of the simple down-dropped type, for its bordering faults are thrust toward the trough in most places along its eastern side and in at least some places on the western side (Stutzer, 1927; Grosse, 1935).

The structure of the bottom of the trough is complex. In the Cauca valley section, recent lake and river deposits conceal most of the trough bottom except along its eastern side where roughly half the width of the trough is taken up by low foothills bordering the west foot of the Central Cordillera (Fig. 16). These, where the writer crossed them by train between Zarzal and Armenia, were found to be composed of poorly consolidated sandstones, shales, and conglomerates (believed to be Late Tertiary to Recent in age) showing rather complex structure but with dominant easterly dips ranging up to nearly vertical. Aerial photographs of the same region reveal the easterly dips and also evidences of at least a moderate amount of folding. Stutzer (1927), after visiting this foothill belt east of Buga, reported recent formations—clays, sandstones, and conglomerates with beds of coarse pebbles—dipping steeply eastward at about 40°.

In the southern third of the trough, drained by the Patía River, the rocks of the trough bottom are broken by numerous faults into blocks trending, as a rule, approximately parallel with the axis of the trough. Grosse (1935), on his map of

the trough, shows also several anticlinal and synclinal folds not broken by faults, but Stutzer (1927, Bd. 57) says that he did not find Tertiary folding in any of his journeys in the Cauca-Patía graben—"All was uplifting and fracturing." In several places the sedimentary rocks of the trough have been broken by igneous intrusions.

GEOLOGICAL SECTION

So far as is known, no Cretaceous sedimentary rocks are exposed anywhere in the Cauca-Patía graben. At the northern end of the trough, Late Tertiary rocks lie directly on schists and intrusives of pre-Cambrian or Paleozoic age (Stutzer, 1927, Bd. 56), while farther south, in the vicinity of Cali and in the Patía section of the trough, the oldest unmetamorphosed sediments belong to an Eocene-Oligocene coal-bearing series similar lithologically to the Guaduas series of the Magdalena trough, and probably to be correlated, at least in part, with that formation.

The Eocene-Oligocene coal-bearing formation is composed mainly of sandstones and shales, but has some conglomerates in the lower part. A thickness of about 1,400 feet is mentioned, but that may not be the maximum. Mostly the formation is continental, but marine fossils have been found at certain horizons.

Lying with apparent unconformity on the coal-bearing formation is a thick section that Grosse (1935) calls Middle Tertiary and which is probably mainly Miocene. The lower part of this section, consisting of about equal parts of sandstones and clays and clay shales has a thickness of 10,000 to 13,000 feet and is free of volcanic material. Parts of it must be marine, for oyster beds have been found. The upper part of the Middle Tertiary section, 3,000 to 10,000 feet thick, contains large quantities of volcanic ash and tuff.

Separated from the Middle Tertiary by a pronounced unconformity are beds of Late Tertiary, probably Pliocene, age that lie, at one place or another, above all earlier rocks of the region. They are mainly coarse tuffs, sandstones, and conglomerates. These rocks cover the plateau which, in the vicinity of Popayán, forms the divide between the Cauca and the Patía sections of the graben.

Alluvial materials of Quaternary age cover considerable areas in the lower part of the trough.

POSSIBILITIES FOR PETROLEUM

As compared with other sedimentary basins in Colombia, the Cauca-Patía trough shows very little direct evidence of the presence of petroleum. Only one true seepage of oil is known. That occurs in the Patía section of the graben, about 11 kilometers southwest of Mercaderes ($1^{\circ} 47\frac{1}{2}'$ N., $77^{\circ} 10'$ W.), where a small amount of dark oil emerges from the lower Middle Tertiary rocks a short distance above an andesite sill interbedded with the sediments.

On the whole, the petroleum prospects of the Cauca-Patía trough do not appear to be very attractive. In the Cauca section of the trough the underlying rocks and the structure are very little known because they are mostly covered by

recent sediments. In the Patía section the geologic conditions, though offering possibilities for petroleum, do not seem very promising. The only rocks in that region that might possibly have generated petroleum are the sandstones and shales of the Early and Middle Tertiary. Those beds are extremely thick, but are believed to be mainly continental in origin, though marine deposits of unknown thickness are undoubtedly present. Furthermore, the structures in the Patía section of the trough seem to be only moderately favorable for oil accumulation.

For the reasons stated, the Cauca-Patía trough is placed on the accompanying map (Fig. 23) in the "possible" rather than in the "probable" class.

ATRATO-SAN JUAN TROUGH

Between the Cordillera Oriental and the much lower Cordillera del Chocó (or Cordillera de Baudó) which borders the Pacific coast of Colombia, is a trough drained in its northern part by the Atrato River and in its southern part by the San Juan. Its total length, including the land on either side of the Gulf of Urabá, is about 320 miles and its width ranges from about 15 miles, on the divide between the Atrato and the San Juan rivers, to 70 miles in the north-central part. The trough is, therefore, considerably wider and longer than the Cauca-Patía graben.

Little seems to be known about the geology of the Atrato-San Juan trough. A cross section along Lat. $6^{\circ} 40' N.$ (Gregory, 1929, p. 166) shows the highlands close to the Pacific to be composed of basic igneous rocks. East of these are metamorphosed shales followed by a much faulted belt of sandstones and tuffs. These are in fault-contact on the east with foraminiferal clays and sandstones showing open-fold structures along their western border and, east of the folds, a relatively uniform dip eastward at a moderate angle to the Atrato River.

The sedimentary rocks in the trough are believed to be Tertiary in age. Seepages of oil and brea are reported along the western border of the trough at the eastern base of the Sierra del Chocó (Ermisch, 1935).

An unfavorable climate is mainly responsible for the fact that the Atrato-San Juan trough is so little known. The rainfall is extremely heavy, the region is low, humid, and unhealthful, and the forest cover is dense. All of these conditions make geological exploration difficult and will interfere with the testing of any favorable oil structures that may be found. The only access to the region as a whole is by the rivers, which, however, are navigable by moderate-sized boats.

PACIFIC COASTAL REGION OF NORTHERN PERU, ECUADOR, AND SOUTHERN COLOMBIA

The coastal region of northern Peru, Ecuador, and southern Colombia includes the important oil fields of the Talara-Negritos, Lobitos, and Zorritos districts of northern Peru and the Santa Elena peninsula of southwestern Ecuador. It has produced a very considerable part of South America's oil, but the area actually

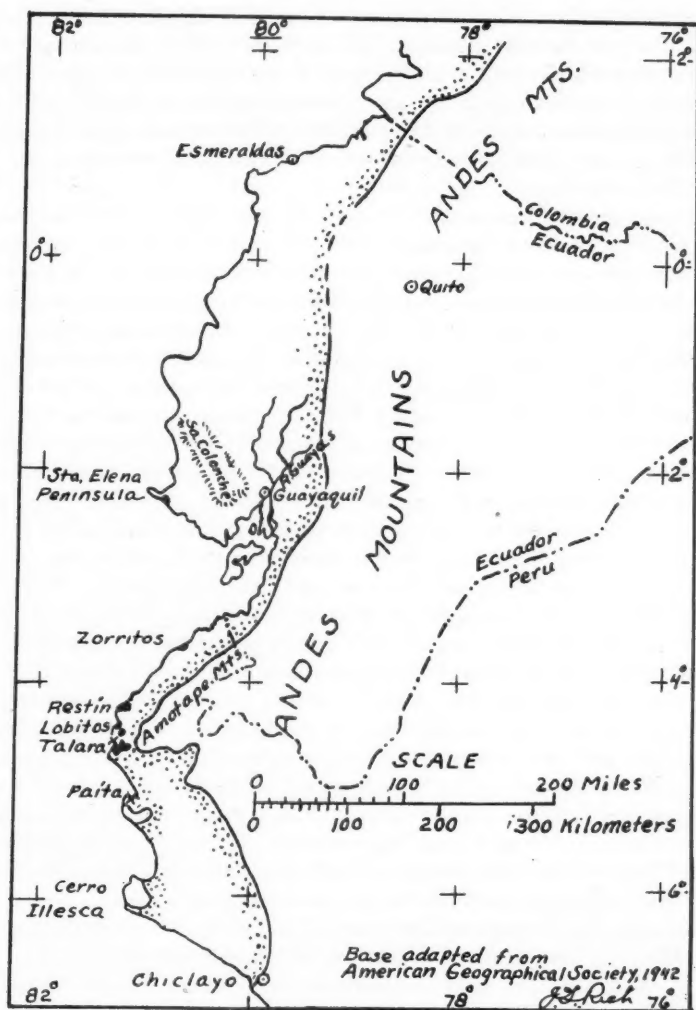


FIG. 17.—Coastal lowlands and oil fields of northern Peru and Ecuador.

productive comprises only a very small part of a large potentially petroliferous region lying between the Andes and the Pacific and having geological conditions somewhat similar to those of the proved fields (Fig. 17).

That region, in the form of a narrow belt about 740 miles long extending from near Chiclayo on the south (Lat. $6^{\circ} 44' S.$), to Buenaventura, Colombia, on the

north (Lat. 4° N.), has a width varying from 16 miles northeast of Talara to about 90 miles in central Ecuador. The belt, as a whole, is underlain by Tertiary rocks lying on unmetamorphosed Cretaceous rocks in the Talara-Paíta region of Peru and perhaps in southern Ecuador, and elsewhere mainly on moderately metamorphosed Paleozoic rocks in the Peruvian part of the belt and probably, according to Olsson (1942), mainly on Paleozoic and older crystalline rocks in much of the Ecuadorian part.

In general, the Cretaceous and Tertiary rocks have been deposited around and lapping against projecting highland masses—perhaps fault blocks—of the older rocks. Such masses now project above the surface near Paíta and in the Cerro Illesca and Amotape Mountains in Peru, and in the Cerros de Colonche and several other projecting masses of older rocks in central and northern Ecuador.

Having been deposited thus, it is to be expected that the Tertiary sediments should vary greatly in thickness, especially those in the lower part of the section, and such a condition is actually found. The most nearly complete section of the Eocene appears to be in the Talara region of northern Peru where over 6,000 feet of Lower Eocene rocks are found that have not yet been discovered in other regions. In general, the Upper Tertiary formations extend more widely than those of the Lower Tertiary and transgress across regions that the latter did not cover.

In northern Peru the Tertiary section is about 25,000 feet thick and includes more than 11,000 feet of Eocene, 8,000 feet of Oligocene, 3,000 feet of Miocene, and somewhat less than 1,000 feet of Pliocene. The total thickness however, is not found at any one place. The Eocene is the thickest of the Tertiary formations and has produced the most oil (Iddings and Olsson, 1928).

Present indications are that the lower part of the Tertiary section may not be present under the wide Sechura desert at the south, between the Talara region and Chiclayo, and the Tertiary is said to be thinner there than farther north. Nevertheless, oil seepages are known along faults (Salfeld, 1933).

In Peru, the Tertiary rocks are almost entirely marine and consist mainly of ordinary shales, sandstones, and conglomerates, with only small amounts of limestone. Volcanic material, though making up an important part of the section in Ecuador, is unimportant in the Tertiary of northwestern Peru.

In Ecuador, the Tertiary section is not so well known as in Peru. On the Santa Elena peninsula, from whence has come all of Ecuador's oil production to date, the oil is found in Eocene rocks at widely varying depths from practically at the surface (where it has been recovered for many years from hand-dug pits) to more than 3,500 feet (Busk, 1938). The region is one of intense faulting complicated by igneous intrusions—apparently dikes and sills—that have considerably baked and silicified the adjoining rocks.

The known Tertiary rocks of the lowlands of western Ecuador are of Eocene, Oligocene, Miocene, and Pliocene age. All are dominantly marine. Probably the Tertiary section is not so thick as in northern Peru, but one could not be sure of that until the region—especially the lowland drained by the Guayas River—has been much more thoroughly tested than it has to date.

In general, Eocene and Oligocene rocks make up most of the coastal area, except in the extreme north of the province of Esmeraldas, where Oligocene and Miocene rocks are at the surface. Miocene rocks have been supposed to underlie most of the Guayas River lowland.

The Tertiary rocks of Ecuador differ from those of Peru in that they contain much volcanic material in the form of ash, tuff, and some agglomerate, as well as numerous intrusive rocks in the form of dikes, sills, and plugs (Sheppard, 1930). Some of these, to judge by available descriptions, are of Tertiary age; others are described as being post-Tertiary, but as in so much of the writing about Ecuador, the descriptions are not specific and the rocks may be merely post-Early Tertiary. According to Sheppard (1933), the dikes have not been observed to penetrate the Miocene or Pliocene.

The prospects for finding additional oil fields in the lowland region of western Ecuador seem to be good, but comparison of the region area-for-area with the oil territory of northern Peru shows two conditions are less favorable. One is the abundance of volcanic material in the Ecuadorian Tertiary section. The other is that, according to Olsson, the Tertiary rocks of Ecuador were deposited lapping against hills of older rock. If this is true, much of the lower part of the Tertiary section may be absent in many places by reason of non-deposition.

Nevertheless, with important oil accumulations proved on the Santa Elena peninsula, it seems certain that others will be discovered. Discovery may not be easy, however, because extensive faulting, former subterranean earth slips like those in Peru (described on a following page), igneous intrusions, marine terraces hiding the surface geology in much of the coastal region, and alluvium covering large areas of the interior, all will impede the search. That the search will be more than ordinarily difficult is proved by the fact that, within the 3 years preceding the end of 1943, seven deep wildcat wells had been drilled by a company using the best current techniques, yet apparently without success (*Oil and Gas Jour.*, December 30, 1943, pp. 112-134).

Little is known of the Tertiary rocks underlying the coastal plain of south-western Colombia, for the region is low, swampy, and densely forested. Consequently rock exposures are few. Nearly horizontal sands and clays of probable Pliocene or Pleistocene age are found near the coast, but farther inland earlier Tertiary rocks evidently have been considerably deformed, for they show dips of 15° to 30° (Olsson, 1942).

STRUCTURE

The structure of the entire Pacific coastal belt of northern Peru and Ecuador is dominated by normal faulting that has broken the region into a series of tilted blocks of various dimensions ranging from small slivers to blocks showing displacement of many thousands of feet. This faulting, together with the lenticularity of some of the sands, has determined the location of the oil accumulations.

Both in Peru and in Ecuador there is evidence of extensive interstratal flowage of the sediments during and soon after deposition, and also of great submarine

earth slips along what might be called low-angle normal faults on slip zones 7° to 10° steeper than the bedding. These appear to have been due to gravity-sliding in a great pile of sediments accumulating on a steep-fronted continental shelf, or, perhaps, in sediments rendered unstable by fault-block tilting while still beneath the sea. The horizontal component of displacement seems in some instances to have been 10 to 15 miles and commonly from 1 to 3 or 4 miles (Baldry, 1938; Brown, 1938). The slip planes are marked by peculiar "clay-pebble" zones which not uncommonly closely resemble glacial till. Pebbles, perhaps from conglomerates lower in the section, and blocks of all sizes from various horizons are embedded in crumpled or sheared and slickensided clay (Fig. 18).

Such low-angle slips make it difficult to decipher the subsurface geology of the region, for there may be no similarity in structure between beds above such a slip zone and those below it. Failure to recognize the presence of such slips can cause and has caused all sorts of difficulties in the interpretation of subsurface structure and stratigraphy.

GENERAL OPERATING CONDITIONS

The Pacific coastal belt here under discussion has the great advantage of accessibility. No part of it is very far from the sea.

The climate in northern Peru and in southwestern Ecuador is semi-arid, and relatively cool and healthful because of a cold-water current off-shore. The vegetation is of the semi-arid type and so sparse as not to interfere with geological exploration or with oil-field operations (Fig. 19).

In northern Ecuador, in the Guayas and Daule river basins, and in Colombia, the climate and vegetation conditions are much less favorable. The rainfall increases northward from light in southwestern Ecuador to very heavy in southern Colombia, and in the north the vegetation cover becomes the typical tropical rainforest. If that region should become productive, the operating conditions will be much more difficult in every way than in the present producing fields.

The topography of all but the northern of the Peruvian fields and of the undeveloped areas at the south is exceptionally favorable for oil-field operations because the surface is that of a very gently sloping, gravel-capped, uplifted marine terrace standing at elevations ranging from less than 100 feet near Chiclayo to more than 1,100 feet north of Lobitos, and extending inland 15 to more than 20 miles—well beyond the limits of the oil fields. Locally, near the sea and the larger streams, the terrace has been dissected into rough bad-land forms (Fig. 19). In the northern portion of the Peruvian area the topography is moderately rough with a relief of several hundred feet, but the vegetation is sparse.

In Ecuador, a belt of hills ranging from about 800 feet to more than 2,000 feet in height extends north and south about half way between the Guayas-Daule River lowland and the coast, and constitutes a considerable barrier, rather densely wooded on its eastern side. Large areas in the Guayas River basin are low and swampy and have a vegetation cover ranging from rather open in the south to dense in the north.

Active exploration for oil is now in progress, especially in Ecuador. In much of the region yet to be explored the nature of the surface rocks makes it impossible to work out details of the geology by surface methods, and therefore much of the geological exploration must be done by geophysical means.

BRAZIL

Five regions in Brazil have been indicated as having prospects for oil production. They are: (1) the Territory of Acre on the Peruvian border at the headwaters of the Juruá and Purús rivers; (2) a trough of Paleozoic rocks, ranging in age from Silurian through Carboniferous, lying on either side of the lower middle course of the Amazon River, and indicated on the accompanying maps by the name "Amazon trough"; (3) the Baía trough (in which oil has recently been found) lying near the Atlantic Coast north of the city of Salvador (Baía), where Cretaceous and probably Late Paleozoic rocks have been downfaulted between the Archeozoic rocks on either side; (4) the Piauí Basin in northeastern Brazil, located largely in the states of Piauí and Maranhão and underlain by a rather unfavorable section of Carboniferous and Permian rocks; and finally (5) the huge Paraná basin of southern Brazil (extending into northern Uruguay and eastern Paraguay) underlain by Devonian, Carboniferous, and Triassic sediments but rendered difficult for oil prospecting by an extensive blanket of lava flows of Triassic age.¹⁰

Nearly half of the area of Brazil is underlain by crystalline rocks of the Guiana shield and of the Brazilian shield, respectively, north and south of the Amazon valley. Over considerable areas south of the Amazon this latter shield is overlain by a relatively thin cover of Paleozoic, Mesozoic, and Tertiary rocks which, however, are mainly continental and are believed to have small possibility of being productive of oil.

ACRE REGION

In western Brazil, on the headwaters of the rivers Juruá and Purús, southern tributaries of the Amazon (Fig. 10), is a southeast-northwest-trending area somewhat more than 400 miles in length (comprising the southwestern part of the Territory of Acre) which lies close enough to the Andes to include part of the eastern side of the sub-Andean trough, together with some of the outlying Andean folds which bring to the surface Cretaceous rocks similar to those in which oil has recently been found in the Agua Caliente field of the Río Pachitea region of eastern Peru about 125 miles southwest.

The Acre region seems to be considered by the Brazilian geologists to be their most promising prospective oil territory, but because of its remoteness and inaccessibility in a densely wooded and unsettled region, little has yet been done to determine its potentialities, and the geology of the territory is but little known.

Most of Acre is underlain by Tertiary red-beds rather extensively mantled,

¹⁰ For a readily accessible general account in English of the petroleum problem in Brazil see Malamphy, 1939.

especially along the rivers, by Quaternary alluvial deposits, but in at least two localities the Cretaceous rocks that underlie the Tertiaries are exposed. The best known of these is in the extreme western part of the territory, close to the Peruvian border, and the other is about 400 miles southeast in southeastern Acre on the headwaters of the Rio Acre.

In the latter region W. Chandless in 1866 found remains of *Mososaurus* and later A. I. de Oliveira (1924), examining the region in detail, found gypsiferous shales of Maestrichtian age dipping northward and overlain with angular unconformity by Cenozoic shales and sandstones. He concluded that in the Maestrichtian epoch lagoonal conditions permitted the deposition of gypsum, but that in the next succeeding epoch (Danian), marine conditions prevailed.

The foregoing description suggests the presence of at least a moderate amount of structural disturbance in the region, but whether or not it was sufficient to control the accumulation of oil will require further explorations to determine.

In the extreme western part of the territory, close to the Peruvian border, the geological conditions are much more attractive and have recently been explored in considerable detail. There a faulted anticlinal fold, the Moa anticline, has been found which brings Cretaceous and older rocks to the surface. It trends roughly N. 15° W. and has been traced for about 75 miles within Brazilian territory (de Oliveira and Leonardos, 1943;¹¹ de Moura, 1937; Oppenheim, 1937; deMoura and Wanderley, 1938). At the northern end, close to the extreme northwestern end of the Territory of Acre, this fold seems to bring the "basement" rocks to the surface, for the Geological Map of Brazil (*Geologia do Brasil*) shows a small patch of Archeozoic rocks there, and immediately south of it, along the trend of the fold, a patch of Carboniferous which Wanderley (1938) found to be "quartzites" unconformably underlying the lowest rocks of the Cretaceous section on the anticline.

The Cretaceous and Tertiary section exposed in the Moa anticline is as follows. At the base is the Moa formation believed to be Neocomian in age, consisting of two beds of sandstone, the lower 100 meters thick, and the upper 300 meters, resting unconformably on "quartzite" in which fossils identified as Carboniferous have been found. These sandstones are tentatively correlated by the Brazilian authors with the Pongo sandstone of the Pongo de Manseriche section previously described by Singewald (1927) and with the Agua Caliente formation named by Moran and Fyfe (1933) in the Rio Pachitea region of Peru about 125 miles to the southwest. Above the Moa sandstones comes the Rio Azul formation consisting of about 800 meters of calcareous shales and thin limestones which are correlated with the Shale-limestone series of the Pongo de Manseriche section. The next higher member is the Divisor formation consisting of 150 meters of white sandstone believed to be correlative with the Huacanqui sandstone of Pongo de Manseriche and with the Sugar sandstone (Arenisca de azucar) of the Pachitea sec-

¹¹ Hereafter this reference is used repeatedly, simply as *Geologia do Brasil*.

tion. Overlying the Divisor formation comes a thick section of red-beds—shales, gypsiferous and calcareous shales, and sandstones similar to that at the Pongo de Manseriche, and Río Pachitea regions of Peru, which is believed to range in age from uppermost Cretaceous through the Miocene and Pliocene.

The Rio Azul member of the section seems to be the only one that might be a likely source for oil. Its thickness of about 2,600 feet is, however, ample to make it attractive.

The Moa anticline is represented in a section made by Moura and Wanderley (and reproduced in *Geologia do Brasil*) as having its eastern flank downthrown by a normal fault. A few miles west of it, on the Peruvian border, a similar faulted anticline is shown. One is tempted to question whether the normal nature of the faults was actually observed, for upthrusts of the anticlines from the west would seem more likely in the circumstances.

The Moa anticline proves the presence in western Acre Territory of marine Cretaceous rocks that may be expected to be petroliferous, but the published descriptions of the region suggest that along a considerable part of the fold the Cretaceous rocks are so thoroughly exposed as to offer little hope for the presence of oil accumulations in them, especially in view of the fact that oil seepages or oil-impregnated sandstones are not mentioned in any of the descriptions. The patches of Archeozoic and Carboniferous rocks at the northern end of the anticline suggest a southward plunge from that area which, if present, may have permitted flushing of near-by parts of the fold.

If, however, the Cretaceous rocks can be found under proper cover, either on the Moa anticline or on others that may be present—but apparently have not yet been discovered—in Brazilian territory, the prospects of their producing oil would seem to be good. It is also possible, if the Moa anticline plunges southward off a local "high," that farther south on the anticline younger rocks may be present between the Carboniferous and the Cretaceous, and that potentially petroliferous marine Jurassic rocks may there be found. Even the Carboniferous may have possibilities if it should be found that the "quartzite" found at the northern end of the anticline is a product of local silicification on a local "high" rather than of regional metamorphism. The presence in it of determinable fossils prompts this suggestion.

The most attractive possibility for discovering oil in quantity in the Territory of Acre seems to the writer to be the chance that other folds or domes in which the Cretaceous is not exposed, as it is in the Moa anticline, may be discovered east of that anticline and elsewhere in the southwestern portion of the Territory, which presumably lies within the sub-Andean trough. The discovery of such structures, if they are present, might be made by aerial reconnaissance, provided the structures have any topographic expression. Otherwise geophysical work would undoubtedly be required, and the terrane and forest cover would make such work exceptionally difficult.

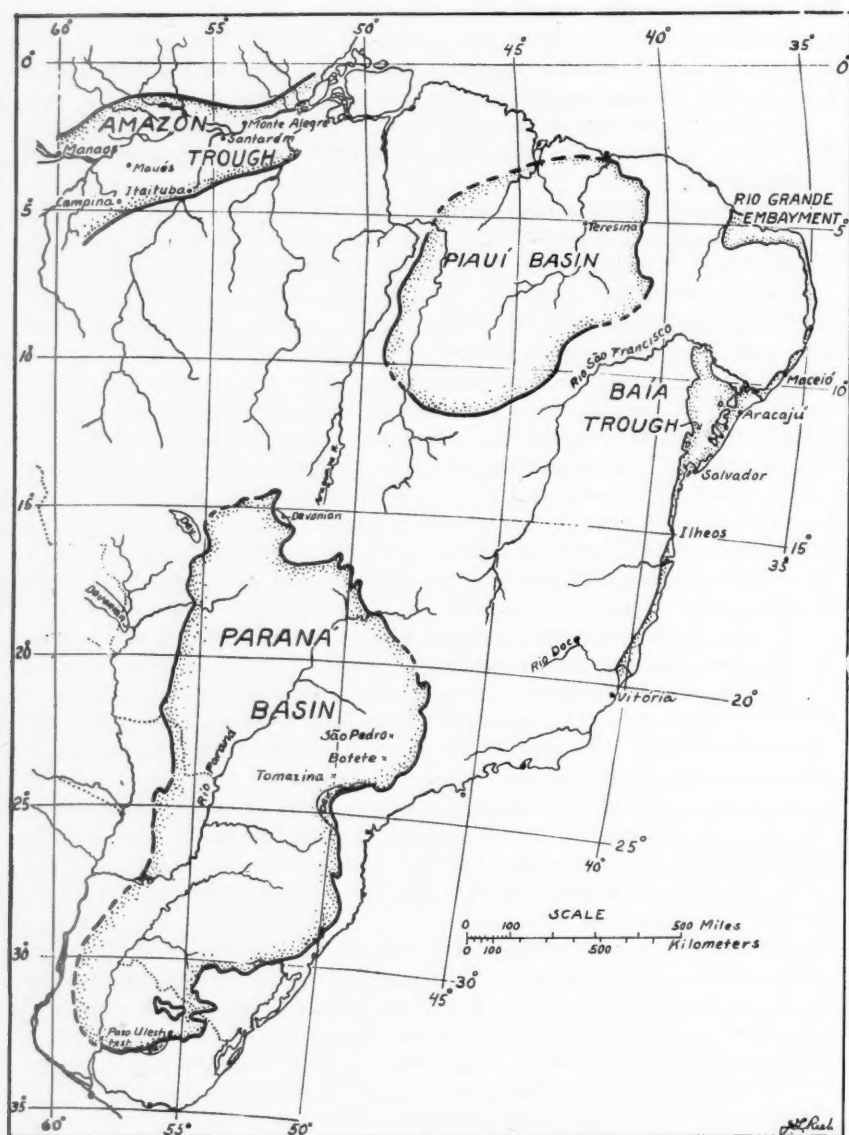


FIG. 20.—Prospective petroliferous basins of eastern Brazil.

AMAZON TROUGH

The lower course of the Amazon for about 600 miles above the head of its delta lies in a shallow synclinal trough of Paleozoic rocks, 125 to 250 miles wide, bordered on both north and south by extensive areas underlain by pre-Cambrian crystalline rocks—the Guiana shield on the north and the Brazilian shield on the south (Fig. 20).

The trough is open at both ends. It is narrowest at the east and widens toward the west to a width about twice as great as at the eastern end. The Paleozoic rocks crop out on both the north and the south sides, and the central axis of the trough is underlain by continental Tertiary sediments that extend unbroken from the head of the Amazon delta to the base of the Andes, widening westward and burying the Paleozoic outcrops on the flanks of the trough and overlapping onto the crystalline rocks of the “shields” on either side.

Any possible widening and deepening of the Paleozoic trough toward the west is effectively concealed beneath the blanket of Tertiary deposits which covers the greater part of the upper Amazon basin. The westward widening of the Paleozoic filling of the trough suggests, however, that Paleozoic rocks may underlie large areas beneath that Tertiary blanket.

The Paleozoic sediments in the trough are almost entirely marine. They include Silurian, Devonian, and Carboniferous. A relatively thin blanket of continental conglomerate and sandstone of Permian age is believed to be present in places.

The Silurian rocks, lying on the crystalline basement, consist almost entirely of quartzite and sandstone of little interest to the petroleum geologist.

The Devonian part of the section is the one which seems most likely to have been the source of any oil that may be present in the trough, because it contains a considerable thickness of dark marine shales, among which oil shales are conspicuous. Most of the Devonian rocks are Lower Devonian (Maecurú group) and Middle Devonian (Curuá group), but at one place, near Monte Alegre, Upper Devonian rocks have been recognized by fossils (*Geologia do Brasil*).

It is very difficult to gain from the printed descriptions of the Devonian of the Amazon trough a clear concept of the section, because most of the accounts are based on river traverses and the sections are described without giving thicknesses, and also because it is extremely difficult for the reader to make any correlations of the sections from one river to another.

Fortunately, two groups of test wells drilled for oil give definite information in two regions, one north and the other south of the Amazon. One group was drilled at Itaituba and at Bom Jardim (only about 2,500 meters from Itaituba) on the Tapajós River about 145 miles above its junction with the Amazon at Santarém, and the other group was drilled about $7\frac{1}{2}$ miles northwest of the city of Monte Alegre, on the pronounced structural dome where uplift brings the Devonian to the surface on a rim-rock-bordered plain about 13 miles across, known as the Chapada de Monte Alegre.

The five wells near Itaituba had an average thickness of 270 meters (880 feet) of Devonian (*Geologia do Brasil*, p. 308). A generalized section of the Devonian in these wells, compiled by averaging the logs of the five wells, beginning at the top, follows.

	Thickness in Meters
Carboniferous.....	Not given
Conglomerate, with shaly lime cement.....	Not given
Argillaceous shale, green, chocolate, and light gray.....	21
Silty shale, with numerous pebbles of pre-existing rocks.....	22
Slaty shale, black, with <i>Lingula</i> , and fish scales.....	117
Shale, siliceous and silico-argillaceous, calcareous, with impregnations of petroleum.....	69
Sandstone, white, yellowish, gray, with shale at base, containing <i>Orbiculoides</i>	Not given

In another place (de Oliveira, A. I., 1938), the logs of two of these wells are given, but only in terms of the thicknesses of rocks belonging to the various geological periods and of the showings of oil, gas, and water. The logs show about 40 meters of Carboniferous above the Devonian and 13 to 14 meters of Silurian below it, resting on the metamorphic pre-Cambrian basement.

In Figure 21 the log of the deepest of these wells (445 meters or 1,460 feet) is drawn to scale and on it has been incorporated the more detailed information of the Devonian section previously listed, on the assumption that the base of the conglomerate there mentioned lies at the top of the Devonian. Plotted in this way, the log indicates that the showings of oil and gas were at or close to the top of the sandstone in the lower part of the Devonian section and that the large flow of water probably came from that sandstone.

The three test wells northwest of Monte Alegre, according to a graphic section and description found on pages 305 and 306 of *Geologia do Brasil*, started at or slightly below the top of the Devonian section. The deepest one, 723 meters (2,372 feet), passed through about 2,070 feet of Devonian rocks, then through about 200 feet of diabase, probably a sill, then into black, carbonaceous shale of undetermined age which it penetrated for about 100 feet.

The Devonian section, as calculated from the graphic section already mentioned, from the top to bottom, follows.

	Approximate Thickness in Feet
Black, fossiliferous shale.....	205
"Siltite".....	348
Shale.....	910
Sandstone.....	702
Black shale.....	100+
Total.....	2,265

A diabase sill about 200 feet thick was penetrated between the last two units of the foregoing table.

The Carboniferous in the Amazon trough is composed principally of white and gray fossiliferous limestones with which are intercalated sandstones and shales and a few beds of gypsum. A water-bearing sand generally lies at the base.

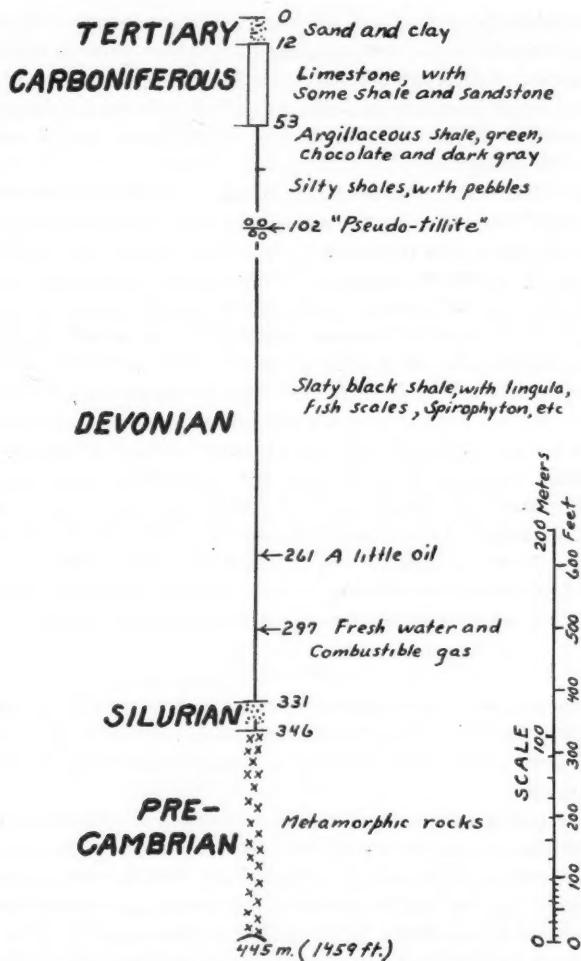


FIG. 21.—Composite graphic log of typical well at Bom Jardim near southern border of Amazon trough. (From data in Oliveira, 1938.)

Derby estimated the thickness of the Carboniferous as 300 to 600 meters, but the greatest thickness actually proved by wells does not exceed 250 meters. One of the wells was at Maués, near the mouth of Rio Maués-Guassú, not far from the axis of the trough and about 165 miles nearly east of Manaus. A well at Campina, about 87 miles south-southwest of Maués, had 246 meters (810 feet) of Carboniferous.

Unconformably above the Carboniferous, in places, may be a small thickness of continental Permian rocks, and unconformably above them, a moderate thickness of continental Tertiary which, on a graphic geological section of the Lower Tapajós River region (*Geologia do Brasil*, p. 348), is indicated as being about 250 meters (820 feet) in thickness in the vicinity of Santarém, on the Amazon close to the axis of the trough.

In a well drilled in the valley of Rio Maués, 57 miles (presumably upriver) from the city of Maués at a little place called Cajú, about 200 meters (650 feet) of Tertiary sediments were penetrated. This place, if it is upriver from Maués, is not far from the southern margin of the Tertiary in the trough; consequently, it is probable that the thickness of the Tertiary is greater nearer the axis.

The Paleozoic rocks of the Amazon trough are cut by numerous dikes and sills and some plugs of diabase. Most of these igneous rocks are believed to be Triassic (Rhaetic) in age. In *Geologia do Brasil*, no older igneous rocks are mentioned, but Katzer (1903) states that granular diabase accompanied by tuffs is interbedded with the Devonian rocks. Such tuffs are not mentioned in *Geologia do Brasil*.

The available descriptions of the Paleozoic rocks of the Amazon trough indicate that the prevailing gentle dip into the trough from either side is broken locally by faults and by dome-like structures. A well defined dome is found northwest of Monte Alegre, a cross section of which, published by Katzer (*op. cit.*, p. 209), shows faulting on its northern side. It appears, therefore, that local disturbances such as might localize oil accumulations are not lacking.

OIL POSSIBILITIES

The Devonian and Carboniferous sections seem promising as generators of oil and, in fact, showings of a yellow-amber-colored oil and combustible gas were found in the wells at and near Itaituba on Tapajós River near the southern border of the trough.

One of the pertinent questions concerning the oil possibilities of the Amazon trough is whether any part of it ever has been deeply enough buried to have promoted the generation of oil from its source rocks. We have little information on the depth of the base of the Devonian in the central part of the basin, but the cross section already mentioned indicates that at Santarém the top of the Devonian lies at about 425 meters (1,400 feet) below the surface and, if the Devonian is as thick there as it is northwest of Monte Alegre (2,435 feet), the base of that formation may be as much as 3,800 feet below the surface.

Farther west in the trough the wells along Rio Maués, already mentioned, showed 200 meters of Tertiary and 246 meters of Carboniferous, giving a minimum depth of 446 meters (1,463 feet) to the top of the Devonian. These depths seem to be great enough to make the trough a promising place in which to search for oil.

That the wells drilled to date have not led to commercial discoveries does not condemn the region. The wells near Itaituba were close to the margin of the

trough, and therefore in a region where flushing might be expected, while the wells northwest of Monte Alegre, though located on a well defined dome, were on a structure cut by numerous intrusions of Triassic igneous rock and one that may be underlain by a laccolith of Triassic age. If such was the origin of the dome, it would have been a "late" structure formed after any oil in the sediments may have completed its initial migration. In that event, the failure to find oil on the dome in no wise condemns the region as a whole. The presence of hot springs on the dome not far from the test wells, and the reported silicification of the rocks near the springs may be further indication that the dome is laccolithic.

Another circumstance that makes the existing wells inconclusive as oil tests of the trough as a whole is that, in both localities tested, the sandstones that might serve as oil reservoirs occur close to the base of the Devonian section and have little favorable source rock below them. It seems that the chances of finding oil are much better in the deeper parts of the trough where both the Devonian and the overlying Carboniferous are buried so that the sandstones and conglomerates near the base of the Carboniferous could function as oil reservoirs.

The region under discussion, traversed by the Amazon River and its tributaries, is one of the most accessible in all of Brazil. It is believed to be one in which the prospects of the presence of oil are fairly good, but where several factors may make the discovery of the oil exceptionally difficult. These factors are: (1) the probability that the dominant structures are due mainly to Triassic igneous activities and hence that many of the most attractive structures may not have been present until after the primary migration of oil had occurred; (2) the possibility that the oil accumulation may have been controlled mainly by stratigraphic traps which, with the general lack of knowledge of the details of the geology of the region, will be difficult to find; (3) the presence of an unconformable mantle of Tertiary continental sediments over the entire axial portion of the trough which will make effective surface geological work impossible; (4) the presence, in the most favorable axial portion of the trough, of the wide floodplains of the Amazon and its tributaries subject to periodic inundation; and finally, (5) the presence of dense tropical rainforest covering considerable parts of the area, and the numerous difficulties associated with work in such an environment.

PIAUI BASIN

In the states of Piauí, Maranhão, northern Goiás, and eastern Pará is a large structural basin having its center at about $8\frac{1}{2}^{\circ}$ S., 45° W. (Fig. 20). Underlain by Triassic, Permian, and Carboniferous rocks, this basin is believed to have moderate possibilities of being oil-bearing. In certain parts, notably the northwestern in Maranhão and eastern Pará, the older rocks are covered by Cretaceous and Tertiary strata that are not thought of as having any oil possibilities in themselves, but which, for at least a considerable part of their extent, cover Carboniferous and perhaps older rocks that may contain oil.

The Piauí basin is very large, measuring nearly 700 by 480 miles. The Per-

mian and Carboniferous rocks at the surface are mainly continental and hence offer little promise of being oil-productive, but at Teresina, a considerable distance out in the basin at approximately 5° S., 43° W., a well drilled for water to a depth of 1,857 feet (566 meters) found 357 feet of marine shales and sandstones of Upper Pennsylvanian (Uralian) age extending from 110 meters to 219 meters, then 204 meters (669 feet) of continental sandstones and shales of Lower Pennsylvanian (Westphalian) age, below which a second marine series was entered which seems to have extended to the bottom of the hole except for an intercalation of continental beds of unspecified thickness at 503 meters (*Geologia do Brasil*, p. 354). The marine sediments are dominantly sandy, but they contain a fair percentage of dark shales. No limestones were mentioned.

The structure of the basin is described as consisting of gentle, almost imperceptible folds. The thickness of the sedimentary filling is not known because the Teresina well represents the deepest penetration of which record has been found. The possibility of the presence of a considerable thickness of beds lower than those penetrated by that well is by no means excluded.

The Brazilian geologists (de Oliveira, 1938) have classified the basin as one that has "unknown possibilities" for petroleum. Their hopes are based more on unknown rocks that may be present under the deeper parts of the basin and on those revealed by the Teresina well than on the observed characteristics of the sediments at the surface.

COASTAL PLAIN OF NORTHEASTERN BRAZIL

The first commercially productive oil wells in Brazil have recently been drilled in the coastal region of northeastern Brazil, in two down-faulted troughs of Mesozoic and early Tertiary rocks, one the Baía trough near the city of Salvador (Baía), and the other in the State of Alagoas near Riacho Doce, a short distance northeast of Maceió (Fig. 20).

Northeastern Brazil is in the main a crystalline-rock highland ranging from 1,000 to 3,000 feet in elevation; but lying between the highland and the sea, almost everywhere along the coast from the eastern boundary of the State of Ceará southward to the Rio Doce at about $19^{\circ} 30'$ S., is a coastal plain underlain by Mesozoic and Tertiary rocks.

For most of this great distance of about 2,500 miles this coastal plain of younger rocks forms a narrow belt only 15 to 40 miles wide between the sea and the highlands, but in two regions—one at the north partly in eastern Ceará and partly in Rio Grande do Norte and the other in the State of Baía north of Baía de Todos os Santos—embayment-like widenings of the coastal plain extend for more than 100 miles inland.

The coastal plain of northeastern Brazil is not a simple one-cycle affair with rocks dipping gently toward the sea. If it were, its oil possibilities would be negligible. Actually only the youngest member of the coastal plain series, the Barreiras formation of Pliocene age, has such relations. The older Tertiary and Meso-

zoic strata underlying the coastal plain have been considerably disturbed, mainly by faulting of the graben type, and not only show dips of 10° to 20° or more at many places, but also have been proved at least locally to have thicknesses of more than 6,000 feet.

The older sedimentary rocks of the coastal plain include Triassic, Cretaceous, and early Tertiary strata at the surface, as well as probable Late Jurassic sediments whose presence has been proved in test wells (Sohn, 1942). In Pliocene time the sea invaded the coastal region of northeastern South America, planing off the outcrops of the deformed Mesozoic and early Tertiary sediments and depositing unconformably over them a mantle of sand and clay—the Barreiras formation—that in most places obscures the underlying rocks and makes the oil geologist's task especially difficult because it not only prevents surface work but also interferes with geophysical investigation of the rocks lying unconformably below it.

It seems probable that the Cretaceous rocks of the coastal plain of northeastern Brazil are down-faulted remnants of a once widespread blanket that may have covered most of northeastern Brazil, for at many places on the highlands in the states of Pernambuco, Parahyba, and Ceará, marine Cretaceous sandstones cap the highest divides, where they were deposited on the peneplaned surface of the crystalline rocks. It is evident, however, that Mesozoic sedimentation was much greater in the region of the present coastal plain than it ever was on the highland farther west, and began earlier, because none of the pre-Cretaceous Mesozoic rocks are present on the highland.

Whether the graben faulting in the coastal region was in progress during Cretaceous and early Tertiary time is an interesting and pertinent problem, solution of which will probably require more information than is now available, but the presence of conglomerates in the Cretaceous and early Tertiary rocks close to the bordering faults suggests contemporaneous faulting.

The down-faulted-trough nature of the Mesozoic and early Tertiary rocks of the eastern coastal region of northeastern Brazil makes it possible that important oil accumulations may be found even where the coastal plain is not wider than the average, as at the locality northeast of Maceió where an oil discovery has recently been made, but the presence of the masking Barreiras formation on most of the coastal plain will no doubt restrict the early search for favorable structures to those places where outcrops of the lower rocks happen to be exceptionally well exposed.

Available information indicates that the second largest "embayment" of Mesozoic rocks—that in the states of Rio Grande do Norte and eastern Ceará—offers little promise for oil accumulation because the Mesozoic rocks there seem to be thin and lacking in favorable structures (*Geologia do Brasil*, pp. 538–539).

In the following paragraphs the geological conditions in the two regions where oil has already been found—the Bafa trough and the Riacho Doce region northeast of Maceió—are described in some detail (Fig. 20).

BAÍA TROUGH¹²

The Baía trough has been most studied in the region west and northwest of the city of Salvador (Baía), where a portion of it is occupied by the bay of Todos os Santos. The trough there is about 32 miles wide and is a down-faulted graben lying between the main crystalline rock mass of the Brazilian highlands on the west and a block of similar crystalline rocks that forms the peninsula on whose southern tip the city of Salvador is situated. The trough is bordered on both east and west sides by faults. Within the trough the sediments have been much faulted and folded as indicated on the accompanying cross section (Fig. 22), taken from

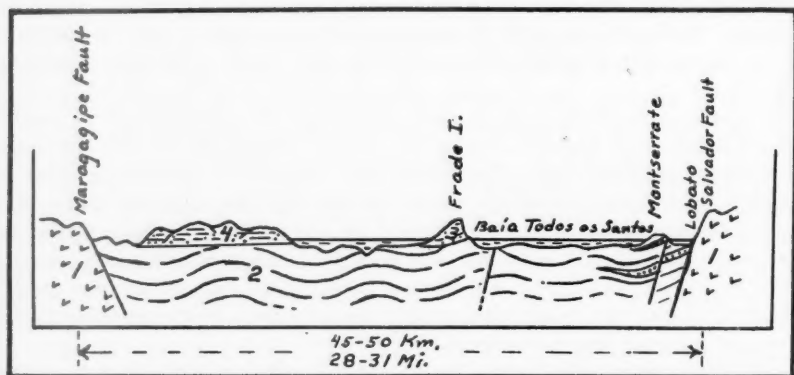


FIG. 22.—Sketch cross section of Baía trough. (After P. Moura, *Geol. do Brasil*, 1943, p. 583.) 1—Basement complex; 2—Baía series (Cretaceous); 3—Islands formation (Cretaceous?); 4—Low Paraguassú formation (Tertiary).

Geologia do Brasil, p. 583. Dips within the trough commonly vary between 10° and 40° .

The trough widens toward the north, and the area underlain by Cretaceous rocks (in part covered with a veneer of late Tertiary sands and clays—the Barreiras formation) reaches a maximum width of about 100 miles and has a maximum length, north and south, of approximately 280 miles, but further exploration is needed before we know whether or not all of this larger area is down-faulted in graben fashion and has a section of sedimentary rocks thick enough to be attractive for oil.

Geophysical observations indicate the presence of more than 2,000 meters (6,562 feet) of sediments in the trough near the north end of the bay of Todos os Santos and one of the test wells already drilled has penetrated them to a depth of more than 5,700 feet (*Geologia do Brasil*, p. 586).

The rocks in the trough that have most interest for petroleum geologists are

¹² For detailed descriptions and maps of the Baía trough, see Fróes Abreu (1936 and 1939).

the Lower Cretaceous "Baía series." Unconformably above these, locally, is a sandstone series several hundred feet thick of possible Miocene age, but in most places the Cretaceous rocks are overlain unconformably by the Pliocene Barreiras formation already described.

The Cretaceous rocks of the Baía series exposed in the Baía trough are fresh-to-brackish-water deposits consisting mainly of silty shales. Sandstone beds are common and limestones are scarce. The latter are generally lenticular or concretionary and are in part chemical precipitates from fresh water. Near the eastern border of the trough, close to the boundary fault, thick beds of conglomerate are found. They are composed mainly of pebbles that might have been derived from the adjacent crystalline rocks, but contain also pebbles of rocks foreign to the region.

Several of the Brazilian geologists who have studied the region have considered it probable that sedimentary rocks older than Cretaceous underlie the deeper parts of the trough and that these may be even more likely than the Cretaceous sediments to be the source of any oil that may be present. This suggestion has partial confirmation in the discovery by Sohn (1942) that brackish-water ostracods from the "Baía group" in cores of one of the wells taken between 1,915 and 2,225 feet indicate a probable Upper Jurassic age for that part of the section.

Considerable test drilling has been done in the trough since the initial discovery on January 23, 1939, of oil at Lobato on the northwestern outskirts of the city of Salvador. One well has reached a depth of more than 1,750 meters (5,741 feet), penetrating shales, conglomerates, and sandstones of the Baía series. Besides the discovery field at Lobato, four other discoveries have been made: the Joanes (adjacent to Lobato), Aratú (12 kilometers north of Lobato, Candeias (about 40 kilometers northwest of Lobato), and on the island of Itaparica west of Salvador (*Geologia do Brasil*, pp. 586-587).

On the map of South America (Figs. 20 and 23) the Baía trough appears very small, but actually it is larger than the Los Angeles basin of California. Having a proved thickness of at least 5,700 feet of favorable sediments its oil possibilities may be considerable.

The official geological map of Brazil indicates that the Baía trough is separate and distinct from the coastal plain north of Salvador. That a barrier of crystalline basement rocks separates the two is suggested by a line of outcrops of these rocks (Fig. 20) extending from the peninsula on which Salvador is situated northward with only minor interruptions (where they are covered by the Barreiras formation) toward the main crystalline highlands about 60 miles up São Francisco River from the coast north of Aracajú.

ALAGOAS REGION

As an example of what may be expected of the coastal plain of northeast Brazil where it has its average width of 15 to 30 miles, a region around Riacho Doce, about 6 miles northeast of the city of Maceió in the State of Alagoas, is

probably typical and certainly is the best known, because it has long been the subject of geological investigation on account of the presence there of rich bituminous shales and small amounts of asphalt-like bituminous material; and because, since 1920, at least nine test wells have been drilled there in the search for oil. Most of these were shallow and were located low on the northwest monoclinical dip (Oppenheim, 1937; *Geologia do Brasil*, pp. 667-668); but one of them, whose location was guided by geophysical investigations, was drilled to 7,037 feet and encountered a good showing of oil.

Most of the region is mantled by the sands and clays of the Barreiras formation already described, but along the coast at low tide and along the shores of some of the lakes that fill drowned valleys excavated at an earlier stage of land uplift, older rocks are exposed which, in the Maceió region, dip 10° to 35° toward the northwest. It is these older rocks, called the Alagoas series, that contain the bituminous shales which have attracted attention to the region.

The rocks of the Alagoas series consist of sands, bituminous shales, conglomerates, and thin beds of limestone in some places containing asphaltic impregnations (Oppenheim, 1937). The shales predominate and the conglomerates constitute only a minor part of the section, but one of great scientific interest because they contain boulders up to a third of a cubic meter in size of the "basement" crystalline rocks and raise the question whether they may have been derived from an uplifted block on the east where the ocean now lies.

The sediments of the Alagoas series are of brackish-water estuarine type, and are very similar in all respects to the sediments of the Baía series of the Baía trough. The fossils in the Alagoas rocks show elements of both Upper Cretaceous and early Eocene, but the consensus seems to be that the beds exposed at the surface should be classified as earliest Eocene.

Geophysical work in the region indicated a thickness of sediments greater than 1,000 meters and much diversity of structure (Malamphy, 1939, Vol. 93, No. 4, pp. 24, 26), but failed to suggest the unexpectedly great thickness of the Alagoas series found in the deep test at Ponta Verde on the coast 3 miles east of Maceió. There the Alagoas series, dipping as steep as 20° , was penetrated to the total depth of the well at 2,145 meters (7,037 feet). By allowing for the dip, this indicates a thickness of more than 6,600 feet.

The Ponta Verde well was drilled on a gravimetric "high." At a depth of 1,500 meters (4,921 feet), it struck a bed of oil-bearing sand that gave an initial production of 15 barrels of oil and 8,964 cubic feet of gas per 24 hours (*Geologia do Brasil*, p. 667). This well is probably not commercial, but it does demonstrate the presence of oil in the section and should give encouragement to further prospecting.

The great difficulty that is bound to impede the search for oil on the coastal plain of northeastern Brazil is the combination of complex structure and an unconformable cover (the Barreiras formation) of sands and clays that, over most

of the area, entirely prevents surface geological study and interferes with geophysical investigations. Another difficulty indicated by what is now known of the structure is that faulting rather than folding seems to be dominant; consequently, favorable traps for oil may be more difficult to find, or their favorable nature more difficult to prove, than if folding were the rule.

The Maceió area, as already suggested, may be considered a type for the average narrow coastal plain stretching for more than 2,000 miles around north-eastern Brazil. In some places conditions may be more favorable for oil and in others they may be less, but almost everywhere the same blanket of late Tertiary sands and clays impedes the working out of the geology. A few places where the coastal belt is wider than the average, as for example, a geological embayment in the lower course of Rio São Francisco between the states of Alagoas and Sergipe, may be proved to have more favorable structures—at least they offer larger areas in which to search for structures—but there, too, the difficulties previously mentioned will be encountered.

PARANÁ BASIN

The largest area in Brazil having possibilities for petroleum—though probably not that having the most attractive possibilities—is the Paraná basin, an oval area about 1,100 miles in north and south extent and 570 miles across, occupying the greater part of southern Brazil, with portions of eastern Paraguay, northern Uruguay, and of the Province of Corrientes and the Territory of Misiones in Argentina.

The basin seems to be relatively shallow, with rocks dipping gently toward its axis from all directions, but no one yet knows how thick the sedimentary rocks are in its central part or what formations are present there. Around the margins, Carboniferous, Permian, and Triassic strata rest on the pre-Cambrian basement except in five places where the basement is overlain by Devonian sediments which are looked upon as having favorable oil possibilities.

The most important Devonian occurrences are: (1) in the State of Paraná; (2) in Mato Grosso northeast of Cuiabá; (3) on the headwaters of Rio Araguaia (ca. 17° S., 51° W.). Two other small areas, perhaps isolated, where Devonian rocks have been found are (1) northeast of Asunción, Paraguay, and (2) in central Uruguay.

From the point of view of the petroleum geologist the most discouraging feature of the Paraná region is that the entire basin, except for a narrow belt around the edges, is covered by a continuous sheet of basaltic lava flows of unknown thickness (estimated as about 2,000 feet) which effectively masks all underlying rocks (Baker, 1923). Over practically all of the southern three-fifths of the basin the lavas are at the surface, while in the northern part they lie below a relatively thin cover of Jurassic and Cretaceous sediments of continental origin, but are exposed in the valleys of many of the larger rivers, especially east of the

Rio Paraná. Besides the lava flows, extensive sills and laccolithic intrusions of diabase have been discovered, partly by surface observation and partly as a result of drilling.

Whatever may be the attractiveness of the sedimentary section in the basin, these masking volcanic rocks make exploration for oil extremely difficult.

The accompanying geological section (Table I) compiled from *Geologia do Brasil* serves as a framework for discussion of the stratigraphic aspects of the oil problem of the Paraná basin, but it should be understood that the section varies considerably from place to place around the margins of the basin and that the definite thicknesses given in the post-Devonian part of the section apply only to the particular spot in the State of Paraná where the section was taken.

The Devonian rocks on the eastern side of the basin occur only in the State of Paraná, having apparently been eroded elsewhere in pre-Carboniferous time. It is remarkable that they occur on the top of a broad arch plunging westward as if, during pre-Carboniferous erosion, they lay and were protected in a synclinal sag which in post-Triassic time became an arch.

In the described section, the beds which are considered to be likely source beds for oil are the Ponta Grossa shales of the Devonian and the Iratí shales of the Permian. The latter are predominantly oil shales, but the Ponta Grossa shales also contain considerable highly bituminous material. In the southern part of the basin, marine beds were reported to be intercalated with the continental and glacial deposits of the Itararé formation. Such beds also might be sources of oil in some parts of the basin.

The structure and the geological section beneath the central part of the basin are unknown. Some have thought that the basin may be comparatively deep and that a thick section of lower Paleozoic rocks may be buried there. Oppenheim (1936), on the other hand, basing his ideas on the fact that the Devonian of Paraguay is different both in fauna and lithology from that of Paraná and Uruguay, suggests that the Paraná basin may not have sagged until the Triassic lavas were poured out, and that in Devonian time the site of the present central part of the basin may have been land. If Oppenheim's ideas are correct, the basin may have little importance as a source of petroleum, whereas, if the alternative supposition represents the true condition, it may hold great petroleum reserves.

The structure of the basin certainly is simple in its major elements. Oppenheim (1935) believes that faulting is very common but Washburne (1935) disagrees. Washburne (1930) gives plausible reasons for believing that the lavas in the central part of the basin are deformed by gentle folds, trending generally east and west, which he thinks are responsible for many of the numerous waterfalls on Rio Paraná and its tributaries, especially those on the east side. He thinks that these folds, especially those on the east side, may be sufficient for the localization of oil accumulations. Certainly any folds or faults that may be present are not sufficiently developed to be expressed strongly in the topography.

TABLE I
GEOLOGICAL SECTION IN PARANÁ BASIN
(Compiled from *Geologia do Brasil*, pp. 312-317, 364)

				Feet
Triassic	Rhaetic	São Bento Series	Basic eruptives, about	2,135
			Botucatú sandstone	200
	Keuper	Rio do Rasto Series	—Local Unconformity— Santa Maria stage (shales, compact clays, and red sandstones)	105
			Terezina stage (variegated shales and sandstones intercalated with them, with lenses and pebbles of siliceous limestone)	302
Permian	Upper	Passa Dois Series	—Unconformity— Estrada Nova stage (dark gray shales with intercalations of thin beds of sandstone and siliceous veins)	345
			Iratí stage (black shale with nodules of limestone, chert, and pyrite)	197
	Lower	Tubarão Series	Palermo stage (grayish yellow sandy shales)	164
Permo-Carboniferous		Tubarão Series	Bonito stage (gray, red, and white shales with intercalations of sandstones and beds of coal, with plant impressions)	940
		Itararé Series	(Glacial conglomerates, fluvio-glacial deposits, conglomeratic sandstones and shales)	154 to 2,300
Devonian			—Unconformity— Ponta Grossa group (shales, dark gray, argillaceous, somewhat sandy and micaceous, fossiliferous, the upper part carbonaceous and phytobituminous. A lenticular sandstone [Tibagy sandstone] locally present)	325 to 650
			Faxina-Furnas group (coarse, clean, light-colored sandstone, locally grading into conglomerate. Furnas sandstone of Paraná)	150 to 985
			Pre-Cambrian basement rocks—schists, granites, <i>et cetera</i>	

OIL POSSIBILITIES

The probable existence of oil in the Paraná basin is suggested by the presence of asphalt-saturated sandstones at several places in the State of São Paulo; by small showings of black, tarry oil in nearly or quite all of the wells as they penetrate the Iratí shale; by small showings in several wells of black, heavy oil in

sandstones not far above the Iratí shales; and, finally, by two occurrences reported by Washburne (1930, 1942) of light, green, paraffinic oil in the tillites of the Itararé formation, one near São Pedro (ca. $22^{\circ} 20' \text{ S.}$, $48^{\circ} 10' \text{ W.}$) and the other at Bofete (ca. $23^{\circ} 5' \text{ S.}$, $48^{\circ} 15' \text{ W.}$). Since the latter oil is very different from the black, tarry oil associated with the Iratí shales, Washburne thinks that its source must have been in deeper beds, perhaps the Devonian.

In 1933 it was reported (Rocha, 1933) that 35 to 40 wells had already been drilled in São Paulo, but no commercial quantities of either oil or gas had been found. Most of these wells were shallow and the majority of them had been drilled without reference to geological structure, but on the other hand, several of them were located on geological advice and were drilled on what seemed to be favorable anticlinal or domal structures. One near São Pedro reached a depth of more than 5,249 feet (1,600 meters). In many places, however, the discovery of diabase in the wells proved that the domed structures had been caused by laccolithic or stock-like intrusions of diabase.

In part, the lack of success in the drilling, to date, may have been due to the fact that most of the test wells were drilled relatively near the eastern border of the basin where water-flushing would have had its maximum effect. All except a few of them are grouped in two relatively small areas. One, in São Paulo, includes São Pedro and Bofete and the territory a few miles east and northeast of those places, and the other in northeastern Paraná near Tomazina. In the latter area the Devonian rocks would be expected beneath the surface, but the wells may not have been drilled deep enough to reach them. At any rate, no mention has been found of any wells having penetrated the Devonian in either state.

After a study of the oil possibilities of the southern end of the basin in Uruguay, Oppenheim (1935) came to rather negative conclusions as to that part of the basin, partly because of the shallowness of the basin in the eastern and central parts of that country and partly because no oil showings have been found in any of more than 35 test wells (most of them shallow), or in outcrops, except asphaltic impregnations in a Triassic sandstone (corresponding with the Botucatú sandstone) in the Department of Rivera, where the impregnations were observed around or in contact with diabasic intrusions.

It is worthy of note, however, that a test well at Paso Ulestie (ca. $32^{\circ} 41' \text{ S.}$, 58° W.), near the western border of the country (at x, Fig. 20), at last reports was still in the Bonito-Itararé rocks at 2,985 feet (910 meters), showing that the sedimentary section there extends to a considerable depth, though 1,181 feet (360 meters) of that depth, near the middle of the hole, was drilled through eruptive volcanic rocks.

In general, it appears that the most favorable part of the Paraná basin—the central part somewhere on a line between the Devonian outcrops in Paraná and those in Mato Grosso and Goiás—has not yet been tested.

It is easy, of course, to suggest such a test, but it is quite another matter to determine the exact spot where it should be drilled, because the region which from

a strictly geological standpoint is considered most favorable, is entirely buried under 2,000 feet of lava!

On the whole, prospecting for oil in the Paraná basin presents exceptional difficulties (Paiva, 1942) brought about by the special features of the basin. These are: the thick Permo-Carboniferous glacial deposits; the irregularities of the glacial deposits, impeding correlation from well to well in them; the presence of unconformities between formations; the presence of sills and laccoliths which in places have bulged the strata, making dome-like structures that appear attractive as oil traps but which actually have not been proved to be such, at least near the margin of the basin; and the lava sheets covering most of the basin, obscuring all of the underlying geology, and impeding geophysical studies of the underlying rock structures. Finally, if oil is found, its extraction will be burdened by the cost of drilling through perhaps 2,000 feet of basalt or diabase. These are some of the reasons which have recently impelled the Brazilian geologists to explore first some of their other possibly petroliferous territory.

SUMMARY

In Figure 23, the information presented on the preceding pages has been assembled in the form of a map of South America on which are shown the areas in which oil has been found, and in which it may reasonably be expected to occur. The possibly petroliferous areas are indicated by three symbols: (1) those which in the judgment of the writer have the best prospects for oil; (2) those having fair prospects; and (3) those that may be proved productive but which for one reason or another seem less attractive than the other two.

The belt of Paleozoic mountain-building that appears to have stretched northwestward across Argentina into northern Chile and Peru separates the region south of it from the rest of the continent. This southern region in Argentina includes among the areas classified as most favorable for oil that near the base of the Andes in the State of Mendoza, where the Upper Triassic rocks have yielded the oil fields of Cacheuta, Tupungato, Barrancas, Refugio, and Lunlunta; the Neuquén basin a little farther south where, in a thick folded section of Jurassic and Cretaceous marine sediments, a number of oil fields have been found and more may be expected; and the basin of San Jorge, on the east coast, in which the Comodoro Rivadavia field has been developed. It includes also a fourth area to which the symbol representing the first grade of attractiveness has been applied, namely, the Magallanes basin in southeastern Patagonia and in adjacent parts of Argentinian and Chilean Tierra del Fuego and of Magallanes. This basin has not yet been proved productive. Also in southern Argentina is an area indicated as having moderately favorable oil possibilities, namely, the Río Negro trough of Upper Cretaceous and possibly Jurassic rocks connecting the Neuquén embayment with the Atlantic.

In northern Argentina, north of the Paleozoic mountain belt, is the Paraná trough extending from the Plata estuary northward past Rosario and Santa Fe,

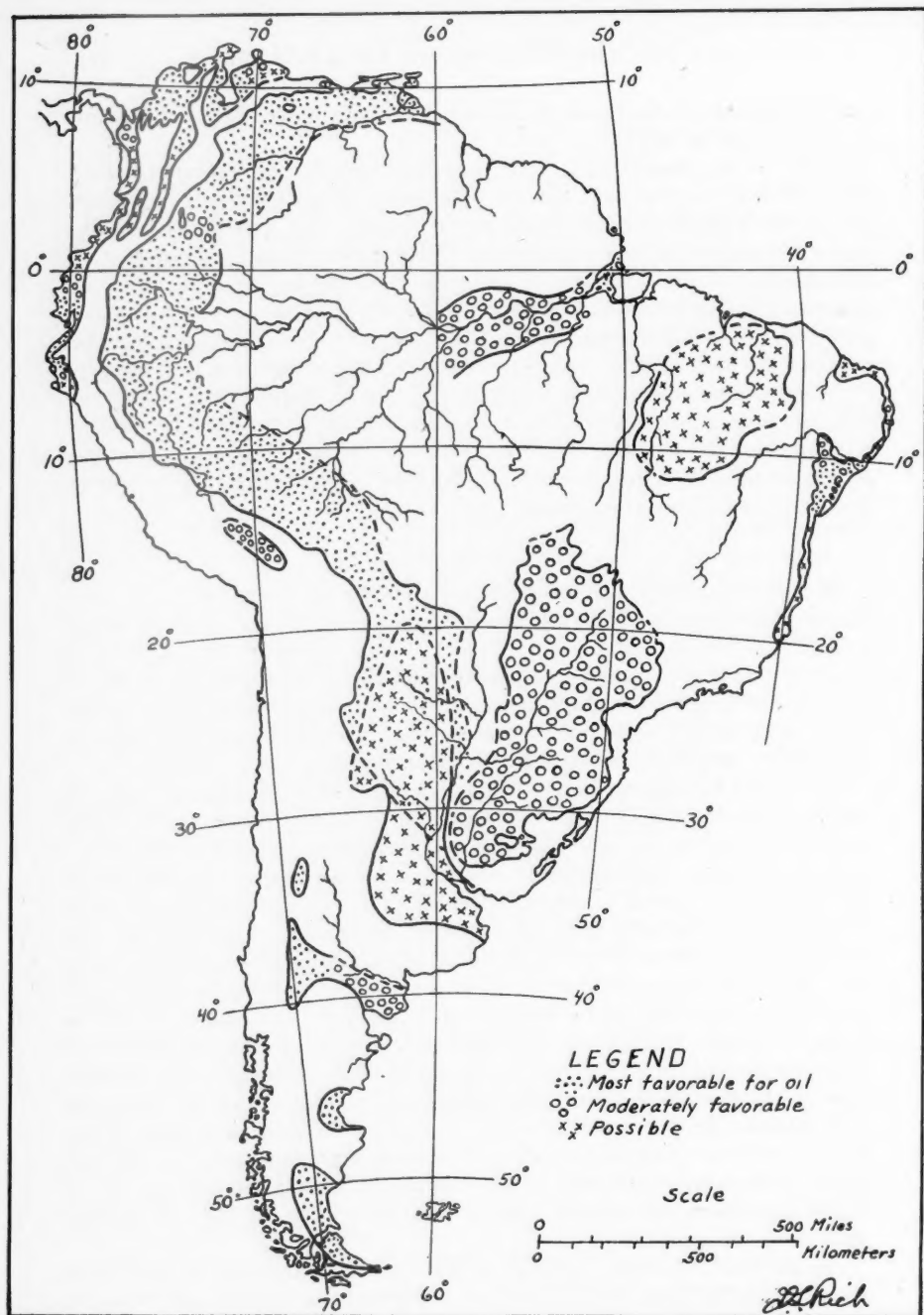


FIG. 23.—Prospective petroliferous basins and troughs of South America: most favorable, stippled; moderately favorable, small circles; possible, crosses.

into the Chaco region of northern Argentina and Paraguay and Bolivia, which during the Miocene was receiving marine sediments. This trough is placed in the third classification because the sediments may not reach thicknesses great enough to be attractive, but the possibility should be held in mind that on account of the great sinking of the sub-Andean trough in northern Argentina and in the Chaco, the sinking may have more than kept pace with the filling from the west so that a thick series of Miocene marine sediments may possibly have been formed. If such is the case, the Late Tertiary sandy beds may be expected to wedge into them from the west and to furnish suitable traps for oil.

In northern Argentina, northwestern Paraguay, and eastern Bolivia, a large area given the highest rating is the Chaco basin, where the probable presence of a thick and favorable section of Devonian and Carboniferous sediments compensates for difficulties of exploration due to an unconformable cover of later rocks and for the great depth at which the oil may be found in much of the basin. The Chaco basin may be looked upon as the expanded southern end of the sub-Andean trough described in the following paragraphs.

The largest area to which the most favorable classification has been given is the sub-Andean trough extending from northern Argentina to Trinidad. This region is now producing oil in northern Argentina and adjacent parts of southern Bolivia, in central Peru, and in eastern Venezuela and Trinidad. It shows numerous oil seepages along the base of the Andes and has favorable rock sections underlying the Late Tertiary gravels derived from the Andes. These rocks range in age from Devonian to Miocene. In many places, as in Peru, Ecuador, Colombia, and Venezuela, on account of the tectonic relation of the sub-Andean belt to the Andean mountain chain, it may be expected that the deepest part of the sub-Andean trough will be found west of its geographic axis and relatively close to the base of the Andes. From this deep part of the trough, the rocks may be expected to rise more gradually toward its eastern border. Since along most of the belt the Mesozoic and Tertiary rocks filling the trough seem to have been derived mainly from the west, it may be expected that numerous sedimentary wedges will be found to pinch out eastward. In so far as these pass the axis of the trough, they should rise at a rate of 40 feet per mile or more toward the east, and their wedged edges should be ideal traps for oil accumulations of the stratigraphic type. It may be found that the central part and eastern flank of the sub-Andean trough, because of its lesser depth and because of the wedging just mentioned, will be more productive of oil than the western flank close to the Andes where an enormous thickness of Late Tertiary gravels, spread out from the Andes, buries the probable oil-bearing rocks to great depths, and where the exposure of the potentially oil-bearing rocks to the intake of artesian water along the base of the mountains may have decreased the value of the structures close along the mountain base.

Among other areas in northwestern South America placed in the first classification are: (1) the Maracaibo basin, whose prolific oil production is well known;

(2) the lower part of the Magdalena trough; and (3) the little-explored lowlands of northern Colombia.

On the west coast, the Talara region of northern Peru and the coastal section of Ecuador seem to offer attractive possibilities for further discoveries. In eastern South America, north of Argentina, the only region given the highest rating is the southern part of the Bafía trough, in which oil has been developed since 1939, and portions of the coastal plain farther north. The area is comparatively small and not much has been published concerning the results of recent exploratory drilling.

The three areas indicated as having moderately favorable possibilities for oil are, in order of preference: (1) the Lake Titicaca region on the Andean plateau where a small productive field has already been discovered, and where a thick section of Devonian, Carboniferous, and Mesozoic rocks is present in broad, open folds; (2) the Lower Amazon trough, where showings of oil have already been discovered around the margins; and (3) the Paraná basin, of enormous size but have a little-known geological section beneath the Triassic lavas, and presenting many obstacles to exploration and development.

Placed in the third classification as having only fair possibilities for oil are: (1) the Piauí basin of northern Brazil; (2) the Rio Grande embayment along the coast of northeastern Brazil in the State of Rio Grande do Norte; (3) the Upper Magdalena valley and the Cauca graben of Colombia; and (4) a strip of lowland along the west coast of Colombia, extending northward from the Ecuadorian border, beyond Buenaventura, and following the valley of Atrato River. Little is known of the last region, but the northern part of the Atrato valley has been placed in the moderately favorable class.

DIFFICULTIES HINDERING EXPLORATION AND DEVELOPMENT IN SOUTH AMERICA

Although a study of the oil possibilities of South America as indicated by its regional geology reveals the present of extensive areas where oil in large quantities may be expected, the finding and producing of this oil present exceptional difficulties. Consider, for instance, the sub-Andean trough, where the greatest potential reserves are believed to be present. In much of that belt, except locally close to the mountain base, the prospective oil-bearing rocks lie at great depths ranging to 15,000 feet or more, and the structures will be difficult to find because of the presence of a thick mantle of Late Tertiary gravel, sands, and silts spread eastward from the growing Andes unconformably over the older rocks. Close to the base of the mountains, the latest folds involve these Tertiary gravels, and will guide prospecting, but over most of the area the search for oil must be by geophysical means.

After the difficulty in finding the oil has been surmounted there will remain the great difficulty of developing it and transporting it. For a distance of about 1,600 miles from central Bolivia to the Llanos of central Colombia, the sub-Andean trough is covered by an unbroken tropical rainforest where the heat and humidity

are trying, and where the presence of virulent tropical diseases require the utmost vigilance in protecting the health of those engaged in the development. Transportation in the region is not yet developed. Heavy rains make road-building difficult, and the streams difficult to cross. The region is separated from its markets by the great Andean range on the one side, and by the Amazon basin on the other.

The difficulties hindering exploration for oil in the Paraná basin of Brazil have already been explained.

Although South America has much territory in which the geological conditions are favorable for the presence of oil, the finding and the development of that oil promise to be more than ordinarily difficult.

REFERENCES CITED

- ÁGUERREVERE, PEDRO IGNACIO (1942), "Geology of the Venezuelan Oilfields," *Proc. 8th Amer. Sci. Congress* (Washington, 1940), Vol. 4, pp. 609-20.
- AHLFELD, FRIEDRICH, and REYES, JORGE MUÑOZ (1939), *Die Bodenschätze Boliviens*. Borntraeger, Berlin. 199 pp. with map.
- ANDERSON, FRANK M. (1926), "Original Source of Oil in Colombia," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 10, pp. 382-404.
- (1927), "Nonmarine Tertiary Deposits of Colombia," *Bull. Geol. Soc. America*, Vol. 38, pp. 591-644.
- (1928), "Notes on Lower Tertiary Deposits of Colombia and Their Molluscan and Foraminiferal Fauna," *Proc. California Acad. Sci.*, Vol. 17, 4th Ser., pp. 1-29. (Review in *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 14, 1930, pp. 108-09.)
- (1929), "Marine Miocene and Related Deposits of North Colombia," *Proc. California Acad. Sci.*, Vol. 18, 4th Ser. (Review in *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 14, 1930, pp. 109-10.)
- BAKER, CHARLES LAURENCE (1923), "The Lava Field of the Paraná Basin, South America," *Jour. Geol.* Vol. 31, pp. 66-79.
- BALDRY, ROBERT ASHLEY (1938), "Slip Planes and Breccia Zones in the Tertiary Rocks of Peru," *Quart. Jour. Geol. Soc. London*, Vol. 94, pp. 347-58.
- BALDWIN, HARRY L. (1942), "Nuevas observaciones sobre discordancias en Neuquén," *Bol. Inf. Petroleras* (Argentina), Vol. 19, No. 214 (June), p. 50.
- (1944), "Tupungato Oil Field, Mendoza, Argentina," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 28, pp. 1455-84.
- BECK, ELFRID (1921), "Geology and Oil Resources of Colombia: the Coastal Plain," *Econ. Geol.*, Vol. 16, pp. 457-73.
- BOWMAN, ISAIAH (1916), *The Andes of Southern Peru*, Amer. Geogr. Soc., New York.
- BROWN, CHARLES BARRINGTON (1938), "On a Theory of Gravitational Sliding Applied to the Tertiary of Ancon, Ecuador," *Quart. Jour. Geol. Soc. London*, Vol. 94, pp. 359-70.
- BUSK, H. G. (1938), "Ecuador," *Science of Petroleum*, Vol. 1, pp. 118-19. Oxford Univ. Press.
- CABRERA LA ROSA, A. (1939), "Descubrimiento de petróleo en Pirín," *Bol. Inf. Petroleras* (Argentina), Vol. 16, No. 180 (August), pp. 57-58.
- CASTER, KENNETH E. (1942), "The Age and Relations of Colombian Devonian Strata," *Proc. 8th Amer. Sci. Congress* (Washington, 1940), Vol. 4, pp. 27-67.
- CHASE, PHILIP W. (1933), "The Geology along the Perene and Tambo Rivers of Eastern Peru," *Jour. Geol.*, Vol. 41, pp. 513-26.
- DOUGLAS, J. A. (1914), "Geological Sections through the Andes of Peru and Bolivia: 1. From the Coast of Arica in the North of Chile to La Paz and the Bolivian 'Yungas,'" *Quart. Jour. Geol. Soc. London*, Vol. 70, pp. 1-53.
- DU TOIT, ALEX L. (1927), *A Geological Comparison of South America with South Africa*, Carnegie Inst. of Washington.
- ENGLEMAN, ROLF (1935), "Geology of Venezuelan Andes," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, pp. 769-92.
- ERMISCH, KARL (1935), "Die Provinz Chocó in Kolumbien," *Pet. Geogr. Mitt.*, Vol. 81, pp. 118-21.
- FERUGLIO, EGIDIO (1938), "Nomenclatura estratigráfica de la Patagonia y Tierra del Fuego," *Bol. Inf. Petroleras* (Argentina), Vol. 15, No. 171, pp. 54-67.
- FOSSA-MANCINI, ENRIQUE (1935), "Las fallas de Comodoro Rivadavia," *Bol. Inf. Petroleras* (Argentina), Vol. 12, No. 136 (December), pp. 65-95.
- (1938), "The Argentine Republic," *Science of Petroleum*, Vol. 1, pp. 120-23. Oxford University Press, London.

- FRÓES ABREU, SILVIO (1936), *Contribuições para o geologia do petróleo no Recôncavo (Bata)*. 232 pp. with geological map. Rio de Janeiro.
- (1939), "O Recôncavo da Bata e o petróleo do Lobato," *Rev. Brasileira de Geografia* (Brazil), Vol. 1, pp. 57-79, with map.
- GERTH, H. (1935), *Geologie Sudamerikas*, T. 2, Borntraeger, Berlin.
- GONZÁLEZ DE JUANA, CLEMENTE (1938), "A Contribution to the Study of the Zulua-Falcón Sedimentary Basin," *Bol. de Geol. y Minería* (Venezuela), Tomo 2 (English edition), pp. 123-40.
- (1944), "Geology of Eastern Venezuela," *Petróleo Interamericano* (Tulsa), Vol. 2 (November-December), pp. 74-80.
- GREENE, R. G. (1939), "Oil on Agua Caliente Anticline, Department of Loreto, Peru," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 23, pp. 688-91.
- GREGORY, HERBERT E. (1913), "Geologic Sketch of Titicaca Island and Adjoining Area," *Amer. Jour. Sci.*, Vol. 36, pp. 187-213.
- GREGORY, J. W., et al. (1929), *The Structure of Asia*, Methuen and Company, London.
- GROEBER, PABLO (1929), "Líneas fundamentales de la geología del Neuquén, sur de Mendoza y regiones adyacentes," *Dir. Gen. de Minas, Geología e Hidrología* (Buenos Aires), Pub. 58.
- (1933), "Confluencia de los Ríos Grande y Barrancas," *Dir. de Minas y Geología* (Buenos Aires), Bol. 38.
- GROSSE, E. (1935), "Acercas de la geología del sur de Colombia," *Compilaciones de los Estudios Geológicos Oficiales en Colombia, 1917-1933*, Tomo III, pp. 139-231.
- HEALD, KENNETH C., and MATHER, KIRTLEY F. (1922), "Reconnaissance of the Eastern Andes between Cochabamba and Santa Cruz, Bolivia," *Bull. Geol. Soc. America*, Vol. 33, pp. 553-70.
- HEDBERG, HOLLIS D. (1931), "Cretaceous Limestone as Petroleum Source Rock in Northwestern Venezuela," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, pp. 229-46.
- (1937), "Stratigraphy of the Río Querecual Section of Northeastern Venezuela," *Bull. Geol. Soc. America*, Vol. 48, pp. 1971-2024.
- , and PYRE, AUGUSTIN (1944), "Stratigraphy of Northeastern Anzoátegui, Venezuela," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 28, pp. 1-28.
- IDDINGS, ARTHUR, and OLSSON, A. A. (1928), "Geology of Northwest Peru," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 12, pp. 1-39.
- IRIZARRY, OSCAR B. (1944), "Eastern Venezuela—A Major Source of Future Oil," *Petról. Interamericano* (Tulsa), Vol. 1 (May-June), pp. 36-47.
- JOCHAMOWITS, ALBERTO (1939), "El petróleo en el Perú," *Bol. Inf. Petroleras* (Argentina), Vol. 16, No. 177 (May), pp. 71-76.
- KATZER, FRIEDRICH (1903), *Grundzüge der Geologie des unteren Amazonas Gebietes*, Max Weg, Leipzig.
- KAYE, M. KAMEN (1938), "Geological Succession of Central Venezuela," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 22, pp. 1224-30.
- LAHEE, FREDERIC H. (1927), "The Petroliferous Belt of Central-Western Mendoza Province, Argentina," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 11, pp. 261-78.
- LIDDLE, RALPH A. (1928), *The Geology of Venezuela and Trinidad*, J. P. MacGowan, Fort Worth.
- MCLAUGHLIN, DONALD H. (1924), "Geology and Physiography of the Peruvian Cordillera, Departments of Junin and Lima," *Bull. Geol. Soc. Amer.*, Vol. 35, pp. 591-632.
- MALAMPY, MARK C. (1939), "Petroleum Problem of Brazil," *Oil Weekly*, Vol. 92, No. 12 (February 27), pp. 114, 119-22, 124; Vol. 93, No. 4 (April 3), pp. 24, 26, 28, 30, 32-34; Vol. 93, No. 9 (May 8), pp. 28, 30, 32, 34.
- MATHER, KIRTLEY F. (1922), "Front Ranges of the Andes between Santa Cruz, Bolivia, and Embatcación, Argentina," *Bull. Geol. Soc. America*, Vol. 33, pp. 703-64.
- MORAN, ROBERT M., and FYFE, D. (1933), "Geología de la región del bajo Pachitea," *Bol. Ofic. Minas y Petróleo* (Peru), Vol. 12, No. 41 (December), pp. 43-54.
- MOURA, PEDRO DE (1937), "Posibilidades do petróleo no território de Acre," *Servicio Fom. Prod. Min.* (Brazil), Avulso No. 16.
- , and WANDERLEY, A. F. W. (1938), "Noroeste do Acre," *Servicio Fom. Prod. Min.*, No. 26.
- NOTESTEIN, FRANK B., HUBMAN, CARL W., and BOWLER, JAMES W. (1944), "Geology of the Barco Concession, Republic of Colombia, South America," *Bull. Geol. Soc. America*, Vol. 55, pp. 1165-1216.
- OLIVEIRA, ÁVELINO IGNACIO DE (1924), "Relatório sobre o vale do Amazonas," *Serv. Infor. Ministério da Agricultura, Ind. e Comércio* (Brazil).
- (1938), "Situação do problema do petróleo no Brasil em 1938," *Div. Fom. Prod. Min.* (Brazil), Bol. 23.
- , and LEONARDOS, OTHON HENRY (1943), *Geologia do Brasil*, 2d ed., Rio de Janeiro.
- OLSSON, AXEL A. (1942), "Tertiary Deposits of Northwestern South America and Panamá," *Proc. 8th Amer. Sci. Congress* (Washington), Vol. IV, pp. 231-87.
- OPPENHEIM, VICTOR (1935), "Petroleum Geology of Central Sedimentary Basin of Uruguay," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, pp. 1205-18.

- (1935), "Petroleum Geology of Gondwana Rocks of Southern Brazil," *ibid.*, Vol. 19, pp. 1725-1805.
- (1936), "Geology of Devonian Areas of Paraná Basin in Brazil, Uruguay, and Paraguay," *ibid.*, Vol. 20, pp. 1208-36.
- (1937), "Geological Exploration between Upper Juruá River, Brazil, and Middle Ucayali River, Peru," *ibid.*, Vol. 21, pp. 97-110.
- (1937), "Geology of the Coast of the State of Alagoas, Brazil," *ibid.*, Vol. 21, pp. 299-310.
- (1942), "Rasgos Geológicos de los 'Llanos' de Colombia Oriental," *Inst. del Museo de la Universidad de La Plata—Notas del Museo de La Plata* (Argentina), Tomo VII, Geol. No. 21, pp. 229-46.
- PAIVA, GLYCON DE; REYES, JORGE MUÑOZ; and MARIACA M., GUILLERMO (1939), "Geología da faixa subandina da Bolívia," *Div. de Geologia e Min.* (Rio de Janeiro), Bol. 101.
- PAIVA, GLYCON DE (1942), "Dificuldades específicas em pesquisa de petróleo no Brasil," *Proc. 8th Amer. Sci. Congress* (Washington), Vol. 4, pp. 621-25.
- REY, P., and OKS, M. (1943), "Coordinación de métodos geofísicos," *Bol. Inf. Petroleras* (Argentina), Vol. 20, No. 230 (October), pp. 3-15.
- RIGGI, AGUSTÍN E. (1938), "Resultados de las investigaciones geológicas en las sierras australes de Buenos Aires y sus correlaciones con otras estructuras de la Argentina," *Rev. del Museo de La Plata* (Nueva Serie), Tomo 1, Sección Geología, pp. 117-28.
- ROCHA, FLEURY DA (1933), "Pesquisa de petróleo em São Paulo," *Bol. do Min. da Agr.* (Brasil), January-December, pp. 463-472.
- ROLL, A. (1939), "Los métodos de exploración en la cuenca de los Estratos con Dinosaurios del Neuquén," *Bol. Inf. Petroleras* (Argentina), No. 180, pp. 14-15.
- ROSSBACH, ALBERTO (1939), "Evolución de los estudios geológicos en el Golfo de San Jorge," *Bol. Inf. Petroleras*, Vol. 16, No. 183 (November), pp. 27-42.
- RUBY, GLEN M. (1944), "Petroleum Exploration in Chile," *Petróleo Interamericano* (Tulsa), Vol. 2, pp. 81-87.
- SALFELD, H. (1933), "Observaciones geofísicas y geológicas en el despoblado de Sechura," *Bol. Soc. Geol. Perú*, t. 5, pp. 67-78.
- SHEPPARD, GEORGE (1930), "Geology of Southwest Ecuador," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 14, pp. 263-309.
- (1933), "Outlines of Ecuadorean Geology," *Pan-Amer. Geol.*, Vol. 59, pp. 45-56; 115-26.
- SINGEWALD, JOSEPH T., JR. (1927), "Pongo de Manseriche," *Bull. Geol. Soc. America*, Vol. 38, pp. 479-92.
- (1928), "Geology of the Pichis and Pachitea Rivers, Peru," *Bull. Geol. Soc. America*, Vol. 39, pp. 447-64.
- SOHN, I. G. (1942), "Upper Jurassic Deposits in Brazil" (abstract), *Bull. Geol. Soc. America*, Vol. 53, p. 1809.
- STEINMANN, G. (1929), *Geologie von Peru*, Winters, Heidelberg.
- STUTZER, OTTO (1927), "Geologische Beobachtungen und Gedanken bei einer zweimaligen Durchquerung der kolumbianischen Mittel Kordillere," *Neues Jahrb. f. Min., Geol. u. Pal.*, Beil. Bd. 56, Abt. B., pp. 135-51.
- (1927), "Beiträge zur Geologie des Cauca-Patía Grabens," *ibid.*, Beil. Bd. 57, Abt. B., pp. 114-70.
- WAHNISH, ESTHER (1939), "Perforación Riachuelo No. 5 Buenos Aires, perfil geológico y descripción de los fósiles," *Rev. Centro Est. del Doc. Ciencias Naturales*, t. 2, pp. 141-56.
- WASHBURN, CHESTER W. (1930), "Petroleum Geology of the State of São Paulo, Brazil," *Com. Geogr. e Geol. do Estado de São Paulo*, Bol. 22.
- (1935), "Rochas Gondwânicas e Geologia do Petróleo do Brasil Meridional" (discussion), *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, pp. 1701-06.
- (1942), "Petroleum Geology of the State of São Paulo, Brazil (discussion), *ibid.*, Vol. 26, pp. 1163-65.
- WASSON, THERON, and SINCLAIR, JOSEPH H. (1927), "Geological Explorations East of the Andes in Ecuador," *ibid.*, Vol. 11, pp. 1253-81.
- WIEDENMAYER, C. (1937), "Comparison of Maturín and Maracaibo Sedimentary Basin, Venezuela," *Bol. de Geología y Minería* (Venezuela), Tomo 1 (English edition), pp. 209-35.

GEOLOGICAL NOTES

NESS COUNTY, KANSAS¹

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Ness County is located slightly east of the center of the west half of the state of Kansas. It includes Ts. 15-20 S. and Rs. 21-25 W. Geologically, it may be described as lying on the southwest flank of the Central Kansas uplift.

Early drilling.—The first exploratory drilling in Ness County was in 1922, when the Community's Strucker No. 1 was drilled in the SE. corner of the NW. $\frac{1}{4}$ of Sec. 1, T. 17 S., R. 26 W. This test was abandoned at the total depth of 3,500 feet without testing any of the possible producing formations below the Permian and without encountering any showings of oil. In 1929 the Continental Oil Company drilled Aldrich No. 1 in the NE. corner of the SE. $\frac{1}{4}$ of Sec. 7, T. 18 S., R. 25 W. This well, which was the third in the county, was drilled to test a local development on a very prominent surface feature which has been called the Beeler anticline.³ The Aldrich well found production in the top of the "Mississippi lime" encountered at 4,422 feet. It was completed at the total depth of 4,427 feet with an initial production of approximately 100 barrels of oil and $\frac{1}{2}$ barrel of water per day.

Development.—The discovery of oil in commercial quantity in the Aldrich field marked the beginning of a pattern of development which is peculiar to Ness County. No attempt was made to extend the producing area until 1936 when the Continental Oil Company drilled Thompson No. 1 in the center of the east line of the SW. $\frac{1}{4}$ of Sec. 13, T. 18 S., R. 26 W., almost 2 miles southwest of the discovery well. The Thompson well was completed in the top of the "Mississippi lime" with an initial production of 576 barrels. In the meantime 4 unsuccessful wildcat wells had been drilled in the county, one of which, the Gypsy's Coleman No. 1, in the center of the SW. $\frac{1}{4}$, NW. $\frac{1}{4}$ of Sec. 25, T. 17 S., R. 25 W., filled with several hundred feet of oil in the top of the "Mississippi lime." By the end of 1944 a total of 49 wells had been completed in Ness County, 22 of which were completed as producers and 27 of which were completed as dry holes. Two new fields had been discovered. The Arnold field was opened by the Sohio Oil Company *et al.* Frevele No. 1, in the center of the SE. $\frac{1}{4}$, SE. $\frac{1}{4}$ of Sec. 22, T. 16 S., R. 25 W., which was completed in November, 1943, with an initial production from the "Mississippi lime" of 142 barrels. The Kansada field was opened by the Skelly Oil Company's Norton No. 1 in the NW. corner of Sec. 23, T. 17 S., R. 26 W.,

¹ Manuscript received, March 26, 1945.

² Consulting geologist.

³ Rycroft G. Moss, "The Geology of Ness and Hodgeman Counties, Kansas," *Kansas Geol. Survey Bull.* 19 (Lawrence, December, 1932).

completed in June, 1944, with an initial production from the "Mississippi lime" of 130 barrels.

Aldrich field.—The Aldrich field by the end of 1944 had been extended so that it consisted of five separate producing areas which, if we are to follow the classification suggested by Lahee,⁴ might properly be called pools. Three of the pools in the Aldrich field produce oil in commercial quantities, and two have produced unprofitable amounts of oil. The pool opened by the Continental's Aldrich No. 1 covers parts of Secs. 5, 7, and 8, T. 18 S., R. 25 W. The pool opened by the Continental's Thompson No. 1 is confined to the S. $\frac{1}{2}$ of Sec. 13, T. 18 S., R. 26 W. The third commercial pool which was opened by the Magnolia Petroleum Company's "B" Olson No. 1 in Sec. 33, T. 17 S., R. 25 W., in June, 1943, now covers parts of Secs. 33 and 34, T. 17 S., R. 25 W. Oil was produced in the center of the north line of the NW. $\frac{1}{4}$, SE. $\frac{1}{4}$ of Sec. 19, T. 18 S., R. 25 W., by S. H. Keoughan *et al.* Tenny No. 1 in January, 1937. The oil in this local area comes from a limestone near the base of the Pennsylvanian and from a sand development in the Sooy conglomerate at the base of the Pennsylvanian. The producing area was limited to 3 wells near the center of Sec. 19. This production has not been profitable. In June, 1938, Schoepel and Elmore's Moses No. 1 found oil in the top of the "Mississippi lime," in the center of SW. $\frac{1}{4}$, NW. $\frac{1}{4}$ of Sec. 10, T. 18 S., R. 25 W. This well was completed, initially producing 599 barrels of oil and 120 barrels of water. No offsets have been drilled.

Aldrich field; spacing.—The Aldrich pool provides a case for the study of spacing in the development of a field. Only 7 wells have been drilled which were 660 feet or less from production. Of these, 2 were dry and 5 were producers. Eight wells have been drilled which were more than 660 feet from production or which were as far as 1,320 feet from production. Of these, 6 were producers and 2 were dry. Three wells have been drilled which were 2,640 feet from production. Of these, 2 were producers and one was dry. All other wells in the field, with the exception of the discovery well and one shallow test, have been 2,600 feet to 10,000 feet from production. Of these wells, 5 have produced and 4 have been dry. In all, 28 wells had been drilled in the field by the end of 1944. If we may arbitrarily assume that all wells drilled 1,320 feet or less from production are development wells and that all wells drilled more than 1,320 feet from production are exploratory wells, 13 wells of the 28 drilled in the Aldrich field were exploratory wells. Of these, 8, or 62 per cent were productive.

Aldrich field; production.—As of July 31, 1944, the 14 wells then producing in the Aldrich field were making 373 barrels per day. The oil was being trucked to the Shallow Water Refinery at Shallow Water, Kansas. The gravity of the oil varies from 33.0° to 35.0°, corrected. The total production for the field including July, 1944, was 727,974 barrels.

⁴ F. H. Lahee, "Standardization in Compiling Data on Exploratory Drilling and Crude Oil Reserves." Presented before American Petroleum Institute, Southwestern District Division of Production, Houston, Texas, June 13-14, 1944.

Geology.—Beds of Upper Cretaceous age are at the surface throughout Ness County. They range from the Greenhorn limestone in the southeastern part of the county to the Smoky Hill chalk member of the Niobrara formation in the north and northwestern part. The north and western parts of the county are partly covered by the Ogallala formation of the Tertiary system. The entire county has been thoroughly investigated and mapped by the surface parties of several of the larger oil companies which have been active in Kansas. In those areas where the beds of the Upper Cretaceous are covered by Tertiary deposits, core drilling has been carried on extensively. Most of the exploratory drilling has been to test prospects which were the result of surface mapping, core drilling, or a combination of the two. Control points have been so scattered that subsurface has been of little value in exploratory work. During the latter part of 1944 several geophysical parties were active in the county. There have been no discoveries in Ness County which are the direct result of geophysical prospecting.

Stratigraphy.—Wells drilled in Ness County begin in beds of Quaternary, Tertiary, or Cretaceous age. The combined thickness of the post-Permian rocks is approximately 900 feet. The Permian is about 2,200 feet in thickness, and the Pennsylvanian has a thickness of approximately 1,400 feet. The "Mississippi lime" in Ness County ranges in thickness from zero thickness in the northeast corner to approximately 250 feet along the south line. The Mississippian problem is complicated by the fact that the upper part of the "Mississippi lime," the section from which the production comes, is "younger" Mississippian of questionable age. Most geologists are inclined to correlate these beds with the Spergen or the Warsaw of Meramec age. The beds below the "Mississippi lime" consist of dolomite, limestone, chert, cherty dolomite, cherty limestone, and sandstone. This series of difficultly correlated beds represents the equivalent of the Kinderhook, the Viola, and the Simpson. The top of the Arbuckle limestone is identified for practical purposes by the presence of oölitic chert.

The tops commonly identified for subsurface work in western Kansas are encountered at the following depths in the Arnold field.

	<i>Sohio et al. Frevele No. 1</i> <i>C., SE., SE. Sec. 22</i> <i>T. 16 S., R. 25 W.</i> <i>Elevation 2,566 Ft.</i> <i>Depth in Feet</i>	<i>Sohio Frevele No. 2</i> <i>C., SW., SE. Sec. 22</i> <i>T. 16 S., R. 25 W.</i> <i>Elevation 2,565 Ft.</i> <i>Depth in Feet</i>
Top anhydrite	1925	
Top Fort Riley	2785	
Base Florence flint	2890	
Top Neva	3125	
Top Howard	3485	
Top Topeka	3615	
Top Lansing-Kansas City	3935	
Base Kansas City	4200	
Top Mississippian limestone	4529	4539
Top Simpson		4795 (questionable)
Top Arbuckle limestone		4869 (questionable)
Total Depth	4564	4900

That part of the "Mississippi lime" which produces in Ness County is, in fact, fine-grained sucrose dolomite. Because of the tubular cavities which are plentiful in the producing bed, the porosity has been described by geologists in the field as "worm-hole" porosity. Laboratory tests of a few core samples have shown both the porosity and the permeability characteristics to be relatively low. This may account for the small initial production in some wells where the pay is apparently well saturated.

There are two principle geologic conditions to which the occurrence of oil in Ness County, at present, appear to be related. There is the pinching-out of the "Mississippi lime" northeast, which may be the result of the Mississippian overlap having reached its northeastern limit, but which is probably due to the post-Mississippian truncation of that part of the "Mississippi lime" section which was deposited over Ness County and the adjacent areas. The second condition to which the occurrence of oil in Ness County appears to be related is a pronounced fold which affects the west half of the county and on which the present producing fields have been found. Oil accumulation on this fold is further controlled by local structure, porosity, and permeability.

Comment.—Development in Ness County has been retarded by several factors, most important of which are generally depressed market conditions, lack of pipeline outlet, relative depth, and unspectacular behavior of the wells. On the other hand, the long-term picture of Ness County is brightened by the high discovery rate, low percentage of normally spaced offsets which are dry, promise of good ultimate recovery, high gravity of the oil, the presence of several possible producing formations (oölitic zone in the Shawnee, oölitic zones in the Lansing-Kansas City, the Fort Scott (?), the Pennsylvanian Sooy conglomerate, Mississippian limestone, Viola limestone, Simpson formation, and Arbuckle limestone), and the abundance of untested territory.

EXCEPTIONAL SILURIAN BRINE NEAR BAY CITY, MICHIGAN¹

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During completion and testing of Gulf Oil Corporation's Salina well No. 1, near Bay City, Michigan, a small amount of very heavy brine was encountered which was found by analysis to be the most highly mineralized natural brine ever recorded. A drill-stem test was made with packer set at 7813 feet, with the hole open to 7883 feet, recovering only a quantity of this brine which weighed 12.1 pounds per gallon. The formation at this depth is porous dolomite containing salt crystals. Salt beds of the Salina formation occur both above and below the dolomite. Cores of the dolomite oozed the heavy brine from pores, on being

¹ Manuscript received, March 30, 1945.

² Chemist, Gulf Oil Corporation.

opened to atmospheric pressure. Estimated bottom-hole pressure was 8,200 pounds per square inch which was apparently the total formation pressure because of the incompetent salt and gypsum beds in the Salina formation. It was found that a 22-pound mud was required to offset the bottom-hole pressure while drilling. Since the brine flow was small, a 16½-pound mud was used which allowed some dilution of the drill mud by the brine.

Samples of the brine were secured both by the drill-stem test and by sampling at the surface when the brine flow had displaced the drill fluid. The drill-stem method secured a representative sample of the Salina brine, the other sample being slightly contaminated with drill fluid. The completed analysis of the drill-stem sample is stated as follows.

GULF'S SALINA NO. 1
SEC. 34, T. 15 N., R. 4 E., MICHIGAN
(Salina dolomite, 7,813-7,883 feet)
Brine analysis, by D. M. Riffin and L. C. Case

	mg./l.	r.v. %
K	21,362	2.39
Na	21	0.00
Ca	206,300	45.02
Mg	7,200	2.59
SO ₄	nil	0.00
Cl	403,207	49.72
HCO ₃	1,208	0.09
Br	3,500	0.19
Total solids	642,798	100.00%
	Sp. Gr.	1.458
	Fe	Large amount
	NH ₄	Present

All constituents in this analysis were determined except sodium, which was computed by difference when balancing positive and negative values. The positive radicals NH₄ and Fe were definitely present and the presence of sodium seems therefore doubtful. Also, consideration of solubility tables strongly indicates that sodium chloride should not be soluble in this bittern.

Because of the high iron content and low pH value of this brine, some additional laboratory work was done on the sample taken from the flow at the well-head. The analysis is stated for comparison at the top of the next page.

It will be noted that this brine contains a relatively large amount of iron. Boiling the sample caused it to become slightly more yellow in color but did not precipitate the iron. This would be expected since the pH value went down on boiling rather than up. This latter fact is positive proof that dissolved carbon dioxide has nothing to do with the pH value. pH values were obtained with Beckman glass electrode after standardizing the instrument with buffers of 3 and 4 pH.

There seems to be no doubt that the iron present in this brine was in solution in the ferrous state. The fact that the pH value went down when the brine was heated seems to be very strong indication of the presence of organic salts of iron.

GULF'S SALINA No. 1

(Hole open from 7,200 to 7,883 feet, brine flowing small stream at surface)

Analysis by Riggins and Case

	mg./liter
K	21,785
Na	4,077
Ca	177,700
Mg	8,440
Fe	500
SO ₄	nil
Cl	361,750
HCO ₃	1,671
Br	3,400
I	5
Total solids	579,328
Sp. gr.	1.415
H ₂ S	nil
pH (as received 9/12/44)	3.0
pH (12/21/44)	3.95
pH (after boiling, 12/21/44)	3.55

The strong organic odor, more evident on heating, was further indication of organic salts which hydrolyze on heating and produce increased acidity. Previous reference has been made in published articles to the occurrence of organic salts of iron in subsurface brines and the probable effect of these organic salts on the corrosion rate in distillate wells.³

A survey of publications shows that the brine from the Gulf's Salina No. 1 has far greater dissolved salt content than any published brine analysis. The salt contents of some well known enclosed lakes are shown as follows.

Description	Great Salt Lake, Utah	Lagoon of Tamentica, Chile	Dead Sea	Elton Lake, Russia	Katwee Salt Lake, Central Africa	Red Lake, Crimea
Total solids, mg./l.	277,000	285,500	260,000	265,000	310,000	300,100
Type of brine*	NaCl-Na ₂ SO ₄	NaCl-Na ₂ SO ₄	MgCl ₂ -NaCl	MgCl ₂ -NaCl	NaCl-Na ₂ SO ₄	NaCl-MgCl ₂

* Only the two dominant salts are stated.

Total salt content of more than 300,000 milligrams per liter is rather common in many subsurface brines of the United States and elsewhere. However, brines containing in excess of 400,000 mg. per liter have not been reported except in Michigan. Some brines of both the Dundee and Sylvania formations in central Michigan have slightly more than 400,000 mg. per liter total dissolved salts.

The Michigan subsurface brines are ordinarily NaCl-CaCl₂ as to type but in some areas the Sylvania brine has much more calcium than sodium and thus the type becomes CaCl₂-NaCl. It should be pointed out that the evaporation of sea water culminates in a bittern rich in the chlorides and sulphates of sodium and magnesium, calcium being absent. It follows that the Michigan brines are not the single result of sea-water concentration. It has been illustrated that closed basins may have saline lakes containing brines of widely different character.

³ Paul L. Menaul, *Oil and Gas Jour.* (November 11, 1944), p. 80.

These brines, or bitterns, have been profoundly altered by the solutions added to them by surface run-off and by resulting precipitation of salts.

It seems safe to conclude that the central Michigan basin had not been connected with the main ocean for a relatively long geological time when the Salina evaporites were laid down. Great beds of sodium chloride were deposited, with thinner beds of gypsum. When calcium chloride approached the concentration shown in the bittern from the Gulf's Salina No. 1, all the sulphate was precipitated as gypsum. The sources of the greatly predominating calcium and chlorine have been variously suggested as volcanic, leaching, chemical interchange, and base exchange. It seems obvious that enrichment in chlorine did take place, which is somewhat more difficult to explain than additions of calcium to the Salina sea.

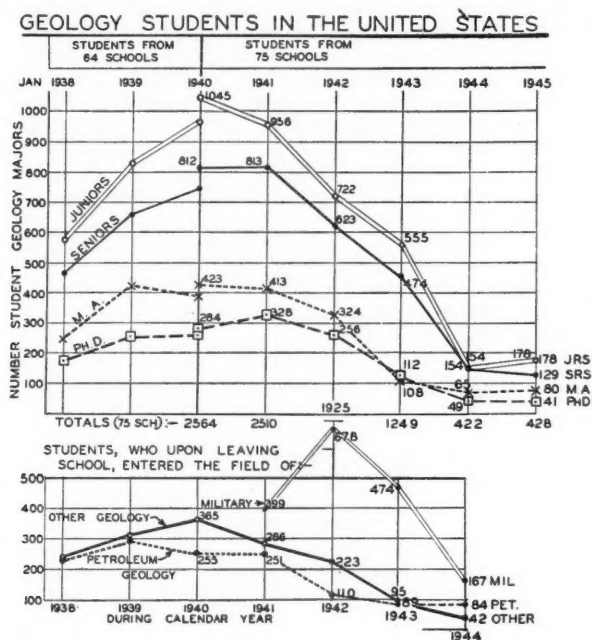
One final observation seems worthy of mention in regard to the Salina bittern. The specific gravity is higher than that of a saturated calcium chloride solution. The specific gravity of saturated potassium and magnesium chlorides is also much lower. The mixture of all these chlorides, plus a small proportion of potassium bromide, gave origin to the viscous, oily-appearing Salina brine, of specific gravity 1.458, which was so hygroscopic that it evolved considerable heat on the addition of fresh water.

RESEARCH NOTE

SURVEY OF COLLEGE STUDENTS MAJORING IN GEOLOGY¹

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The chart is a continuation of the surveys of recent years. It shows the trend in the number of college students majoring in geology in the United States and the placement



of those leaving school during the calendar year 1944. The latest figures are for January, 1945. Of the 75 colleges reporting, 10 report no geology majors, 5 report one each, and 9 report only two each. Probably with few exceptions, the 428 geology majors shown in January, 1945, are persons not eligible for military service, women, or foreign nationals.

¹ Manuscript received, March 21, 1945.

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RECENT PUBLICATIONS

* Subjects indicated by asterisk are in the Association library, and are available, for loan, to members and associates.

CALIFORNIA

*"An Experimental Water Flood in a California Oil Field," by E. C. Babson, J. E. Sherborne, and P. H. Jones. *Petrol. Tech.*, Vol. 8, No. 2 (New York, March, 1945). 9 pp., 4 figs., *A.I.M.E. Tech. Pub.* 1816.

GENERAL

*"Calculation of Static Pressure Gradients in Gas Wells," by M. J. Rzaza and D. L. Katz. *Petrol. Tech.*, Vol. 8, No. 2 (New York, March, 1945). 14 pp., 10 figs. *A.I.M.E. Tech. Pub.* 1814.

*"Petroleum Engineering Education and the Quantitative Approach," by Harry H. Power. *Ibid.* 8 pp. *A.I.M.E. Tech. Pub.* 1815.

*"Measurement of Capillary Pressures in Small Core Samples," by G. L. Hassler and E. Brunner. *Ibid.* 10 pp., 5 figs. *A.I.M.E. Tech. Pub.* 1817.

*"Average Permeabilities of Heterogeneous Oil Sands," by W. T. Cardwell, Jr., and R. L. Parsons. *Ibid.* 9 pp., 3 figs. *A.I.M.E. Tech. Pub.* 1852.

*"Evaluation of New Geophysical Methods," by W. M. Rust, Jr. *Oil and Gas Jour.*, Vol. 43, No. 48 (Tulsa, April 7, 1945), p. 62.

*"Six Different Engineering Methods Compared in Study of Pay Formations," by Kenneth B. Barnes. *Ibid.*, pp. 70-73; 4 figs.

*"Resources and Resourcefulness," by Ira H. Cram. *Oil and Gas Jour.*, Vol. 43, No. 47 (March 31, 1945), pp. 166-67; photo.

**Idem*, *Oil Weekly*, Vol. 117, No. 5 (Houston, April 2, 1945), pp. 34, 38, 48.

Principles of Physical Geology, by Arthur Holmes. 532 pp., 262 figs., 95 pls. Outside dimensions, 5.5×8.25 inches. Cloth. The Ronald Press Company, 15 East 26th Street, New York (1945). Price, \$4.00.

OKLAHOMA

*"Water Flooding in Oklahoma," by David M. Logan. *Oil Weekly*, Vol. 117, No. 5 (Houston, April 2, 1945), pp. 40-48; 5 figs.

ROCKY MOUNTAINS

*"Vigorous Exploratory Play Focuses Attention on Rocky Mountain Area," by Charles J. Deegan. *Oil and Gas Jour.*, Vol. 43, No. 44 (Tulsa, March 10, 1945), pp. 41-42, 47; 2 maps.

*"Important Developments in Rockies Center around Four Great Basins." *Ibid.*, Vol. 43, No. 45 (March 17), pp. 58, 60, 63-64; map.

*"Electrical Logging widely Employed in Rocky Mountain Exploratory Tests." *Ibid.*, Vol. 43, No. 48 (April 7), pp. 60-61; 1 map.

TURKEY

*"Géologie et ressources minérales de la région de Malatya (Turquie)" (Geology and Mineral Resources of the Region of Malatya, Turkey), by V. Stchepinsky. *Maden Tetkik ve Arama*, Sene 9, Sayı 1/31 (Enstitüsü Mecmuası, Ankara, May, 1944), pp. 93-104. In French. Also in Turkish (pp. 70-88). Contains folded geologic map and list of fossils.

*"Contribution a la connaissance du Permo-Carbonifère du Taurus entre Kayseri Malatya" (Permo-Carboniferous of the Taurus Mountains between Kayseri and Malatya), by Maurice M. Blumenthal. *Ibid.*, pp. 118-33. In French. Also in Turkish (pp. 105-18; 4 pls. (2 geologic maps, geologic cross sections, and 6 photomicrographs).

THE ASSOCIATION ROUND TABLE

MINUTES, THIRTIETH ANNUAL BUSINESS MEETING
MAYO HOTEL, TULSA, OKLAHOMA
MARCH 27, 1945

IRA H. CRAM, *presiding*

The meeting was called to order at 9:15 A.M., Tuesday, March 27, 1945, by Ira H. Cram, president.

1. *Resolutions committee.*—The president appointed a resolutions committee composed of W. B. Wilson, chairman, W. T. Thom, Jr., Stanley G. Wissler, Ben F. Parker, and Robert J. Riggs.

2. *Nomination of officers.*—The president called for nomination of officers of the Association for the ensuing year. The following nominations were made.

For president: M. G. CHENEY, Coleman, Texas, nominated by C. W. Tomlinson.

Nomination seconded by S. A. Thompson.

Motion to close the nominations was duly seconded, put, and carried.

Motion to instruct the secretary to cast the unanimous ballot for M. G. Cheney as president, duly seconded, put, and carried.

For vice-president: M. GORDON GULLEY, Pittsburgh, Pennsylvania, was nominated by Ben F. Parker.

Motion to close the nominations was duly seconded, put, and carried.

Motion to instruct the secretary to cast the unanimous ballot for M. Gordon Gulley as vice-president, duly seconded, put, and carried.

For secretary-treasurer: EDWARD A. KOESTER, Wichita, Kansas, nominated by F. L. Aurin.

Motion to close the nominations was duly seconded, put, and carried.

Motion to instruct the secretary to cast the unanimous ballot for Edward A. Koester as secretary-treasurer, duly seconded, put, and carried.

For editor: GAYLE SCOTT, Fort Worth, Texas, nominated by W. T. Thom, Jr.

Motion to close the nominations was duly seconded, put, and carried.

Motion to instruct the secretary to cast the unanimous ballot for Gayle Scott as editor, duly seconded, put, and carried.

3. President Cram read his president's report.

Meeting recessed until 4:00 P.M., March 27, 1945.

The recessed meeting was called to order by president Cram at 4:00 P.M.

4. *Reading of minutes.*—It was moved, seconded, and carried, the minutes of the last annual meeting held at Dallas, Texas, March 22, 23, 1944, be not read since they have been published in the Bulletin.

5. *Report of officers.*—The reports of president Ira H. Cram, secretary-treasurer Robert E. Rettger, and editor Gayle Scott were read (Exhibits I, II, III).

6. *Report of resolutions committee.*—The report of the resolutions committee was read by W. B. Wilson, chairman (Exhibit IV).

7. *Report of business committee.*—The report of the business committee was read by George S. Buchanan, chairman.

It was moved, seconded, and carried that the report of the business committee be accepted (Exhibit V).

President Cram read the following recommendations of the executive committee.

8. *Affiliation of Wyoming Geological Association.*—The executive committee recommends that the Wyoming Geological Association be accepted as an affiliated society of the Association.

It was moved, seconded, and carried, that the Wyoming Geological Association be accepted as an affiliated Society of the Association.

9. *Civil Service resolution*.—The executive committee recommends the adoption of the following resolution.

Whereas, the Veterans Preference Act, Public Law No. 359, 78th Congress, Section 5, provides that:

"No minimum educational requirements will be prescribed in any civil service examination except for such scientific, technical, or professional positions the duties of which the Civil Service Commission decides can not be performed by a person who does not have such education"; and—

Whereas, the United States Civil Service Commission in announcement No. 343 reveals that it is accepting applications for War Service Appointments as Geologist with no written test required, and that educational qualifications will be wholly subordinated to experience requirements, the adequacy of which will be determined by the United States Civil Service Commission which is free to exercise its own judgment in this matter without specified standards of any kind, or, at its discretion, even without the advice of competent members of the profession; and—

Whereas, satisfactory passage of the written examination required for appointment to positions with the United States Geological Survey is generally accepted in the profession, as prime facie evidence of the possession of minimum qualifications for technical excellence in the several grades for which examinations were given; and—

Whereas, it seems clear that if educational training is eliminated as prerequisite to positions in the Government service for which it has long been required, that persons possessing the recognized and conventional training necessary in any one of the sciences may hesitate to enter Government service and the public interest may thus suffer seriously; and—

Whereas, we believe that professional standards are jeopardized by these events to the detriment of the public welfare:

Now, therefore: *Be it resolved*, that the American Association of Petroleum Geologists, comprising a membership of 4,326 qualified members of the profession, most earnestly and emphatically protests to the United States Civil Service Commission its action in these premises and protests the thesis upon which this action is based; and—

Be it further resolved, that the American Association of Petroleum Geologists, recognizing that full discretion is allowed the United States Civil Service Commission in this matter under the statute quoted above, urges that the United States Civil Service Commission withdraw its announcement of November 20, 1944, and restore the minimum educational requirements for geologists theretofore prescribed and further urges that as soon as practicable the former measures of control be restored by including the giving of assembled examinations formulated by experienced geologists. These measures are believed essential to preserve and maintain the technical excellence of geologists employed by the federal services in the interest of the public welfare; and—

Be it further resolved, that this resolution be spread upon the minutes of this meeting of the Association, and that copies thereof be sent to the Chairman of the United States Civil Service Commission, the Secretary of the Interior, the Director of the United States Geological Survey, the Director of the United States Bureau of Mines, and the Director of the Office of Scientific Personnel of the National Research Council.

It was moved, seconded, and carried to adopt the resolution as read.

(The following reports appear as exhibits as part of the minutes.)

- I. President, Ira H. Cram
- II. Secretary-treasurer, Robert E. Rettger
- III. Editor, Gayle Scott
- IV. Resolutions, W. B. Wilson, chairman



Washington Press-Photo Bureau

FIG. 1.—Monroe G. Cheney, president of the Association, elected at Tulsa.



FIG. 2.—Outgoing and incoming executive committees of the Association. Incoming officers, seated, left to right: Edward A. Koester, secretary-treasurer; Gayle Scott, editor; Monroe G. Cheney, president; M. Gordon Gulley, vice-president. Outgoing officers, standing, A. Rodger Denison, past-president; Ira H. Crani, president; Robert E. Retiger, secretary-treasurer; Warren B. Weeks, vice-president.

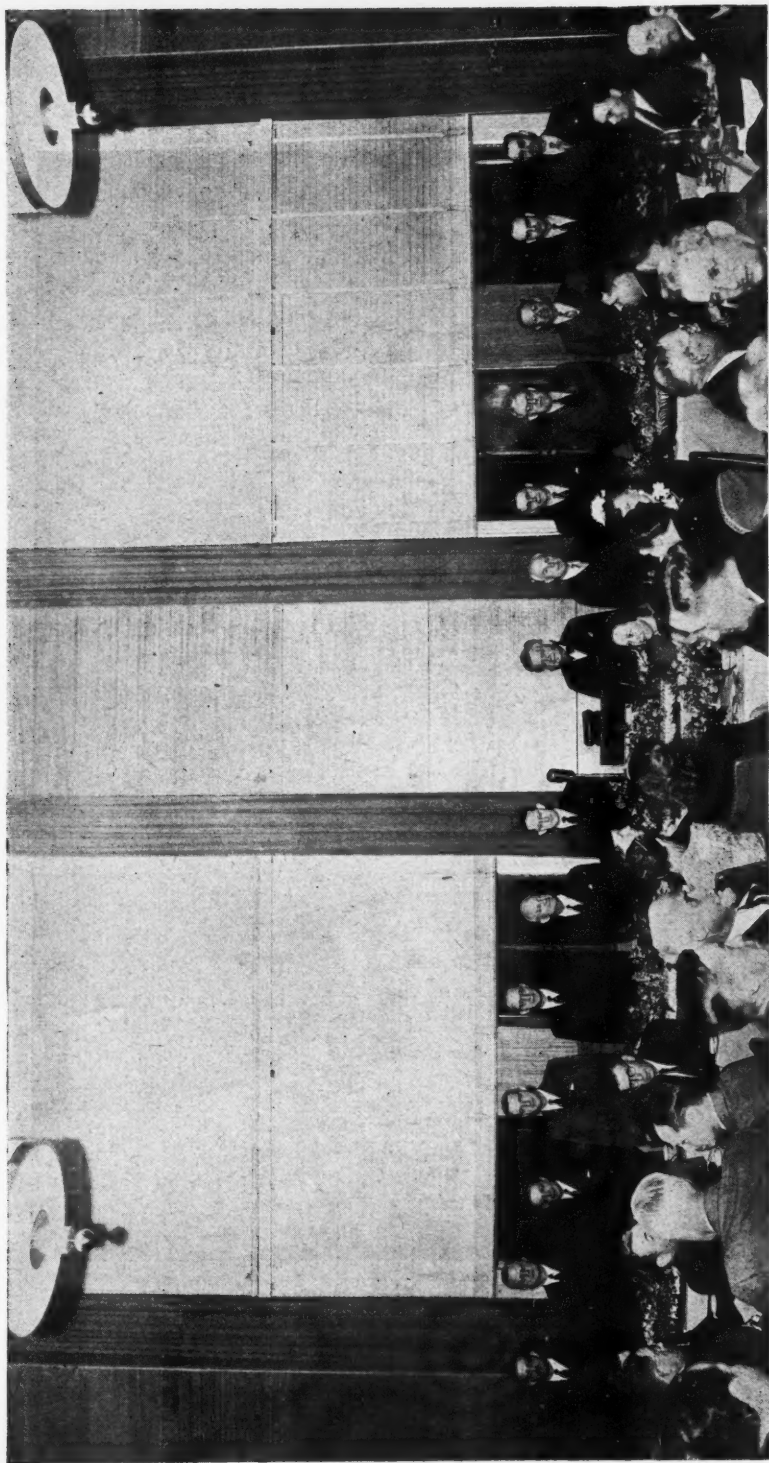


FIG. 3.—Officers and guests at speakers' table at dinner at Tulsa Club, thirtieth annual meeting, March 27. Standing, left to right: Edward A. Koester, Robert E. Rettger, M. Gordon Gulley, William E. Wallace, A. Rodger Denison, Wallace E. Pratt, Ira H. Cram, E. DeGolyer, Vincent C. Illing, Monroe G. Cheney, J. V. Howell, Gayle Scott, Warren B. Weeks, J. P. D. Hull.



FIG. 4.—E. DeGolyer (right), of Dallas, Texas, receiving certificate of honorary membership from president Ira H. Cram (left).



FIG. 5.—William E. Wallace (center), of Shreveport, Louisiana, receiving certificate of president's award from president Cram (left). E. DeGolyer, seated.



FIG. 6.—Wallace E. Pratt (standing left), Powers Memorial medalist, about to respond after receiving the medal from president Cram (right). Seated at left, A. Rodger Denison; seated at right, E. DeGolyer.

- V. Business, George S. Buchanan, chairman
- VI. Code of ethics, C. W. Tomlinson, chairman
- VII. Method of election of officers, John G. Bartram, chairman
- VIII. National service, K. C. Heald, chairman
- IX. Geologic names and correlations, John G. Bartram, chairman
- X. Applications of geology, Paul Weaver, chairman
- XI. Medal award, A. Rodger Denison, chairman
- XII. Distinguished lectures, John L. Ferguson, chairman
- XIII. Publication, J. V. Howell, chairman
- XIV. Research, M. G. Cheney, chairman
- XV. National Research Council Division of Geology and Geography, M. G. Cheney, representative

The thirtieth annual meeting adjourned at 5:05 P.M.

IRA H. CRAM, *president*

ROBERT E. RETTGER, *secretary*

EXHIBIT I. REPORT OF PRESIDENT

(Year ending March 27, 1945)

Your president and associates on the executive committee discharge many routine duties prescribed by the Constitution. We believe that you do not expect a detailed report on all these activities. The secretary-treasurer will report on membership and finances, and the editor will report on publications. These reports indicate encouraging progress. I shall limit my accounting of executive committee activities to those not fully covered in these two reports.

During the year I discussed Association affairs with groups of geologists in 16 cities, and only regret that time was not available to visit at least every one of the 25 affiliated societies. It was my purpose to bring before these local groups certain ideas shared by the other members of the executive committee, and to obtain suggestions and criticisms. I found no group barren of good ideas. In these discussions it was pointed out that the duty of all officers, and of every member and associate, for that matter, is to push the growth of the Association—growth not in size alone, but growth in stature. This growth is accomplished by increasing the number of qualified members, by enlarging the quality and quantity of publications, by stepping up our research efforts, by increasing our effectiveness in the exploration for, and exploitation of, oil and gas fields, and by increasing our interest in all affairs of the profession, particularly those of the Association. The phenomenal growth in stature of the Association in the 28 years of its existence is perhaps not fully appreciated by many members. I assure you that the Association's standing in the scientific and business worlds is unquestionably of the highest, and, further, that there is no evidence whatever of our starting on the road to decadence after having reached a peak of usefulness. There are still opportunities for further growth upon which we must capitalize.

Membership continues to increase, but there are many qualified geologists, petroleum engineers, geophysicists, teachers and others who are not members. There are former members who are still qualified and associates who are qualified for transfer to active status. The large reservoir of potential members can be tapped more effectively if each member, in effect, assumes the chairmanship of the membership committee and acts accordingly. Machinery has been set in motion to encourage former members to come back into the fold, and to encourage qualified associates to apply for transfer to active status.

It is not necessary to stress the fact that all members of the Association benefit from a large membership of qualified geologists, engineers and associated earth scientists. Furthermore, the desirability of expanding foreign membership should be obvious.

The Association's major project is its publications, and their excellence is the chief reason for the Association's high standing in the scientific world. There is a large reservoir of unpublished information, foreign and domestic, of unquestionable scientific and economic merit, that could be published to the advantage of everybody concerned, and to

the detriment of no one. Within this reservoir lies the material for raising the Association's prestige to greater heights. I am happy to report that certain companies are relaxing former restrictions on publication, and it can be hoped that more will see the light. The executive committee has devoted a great deal of time to the study of the problem of increasing the quality and quantity of the Association's publications. Although our efforts were not eminently successful, progress has been made in spite of the adverse war-time atmosphere. Again each member and associate can assist the Association to grow, first, by writing that paper he or she has been hoarding, and, second, by encouraging others to put in print their worthwhile ideas.

Both the executive and research committees have during the year considered carefully the question of the proper function of the Association in research in petroleum geology. It was generally agreed that the Association should not, at least at this time, attempt to raise and administer large research funds. It was further agreed that the sizeable funds which may be available for research will probably not come out of hiding until a well thought-out, comprehensive program of research has been developed and recommended by those competent to speak with authority. In the field of petroleum geology the Association is certainly qualified to speak with authority, and should speak. It is no small task to develop well-thought-out and well organized research projects, and to decide which ones are most desirable to include in a broad, comprehensive program. The research committee needs the help of every member. Even if the ideal is not reached, nothing but good can result from the devotion of more serious thought and effort to the problems of research by every member and associate. Worthwhile projects which the Association can carry on without further financial aid will without doubt be suggested.

In an effort to stimulate further the younger members and associates, the executive committee, on advice of the medal award committee, established the President's Award. This award of \$100 in cash, plus a suitably worded certificate, is to be given to the author or authors of the most significant paper on petroleum geology contributed to the *Bulletin* by authors who had not reached their 40th birthdays on January 1 of the year in which the article is published. The Sidney Powers Memorial Medal Award fund was completed during the year. The first recipients of both awards have been chosen by action of the medal award and executive committees, Wallace Everette Pratt being the recipient of the Sidney Powers Memorial Medal, and William Edwin Wallace, Jr., being the recipient of the President's Award. The establishment of these awards is another step in the process of building up the prestige of the profession and of the Association.

Taking due cognizance of the constitutional provision that those "who have contributed distinguished service to the cause of petroleum geology" may be elected as honorary members, E. DeGolyer was elected to honorary membership during the year.

Past-president Denison represented the Association at the constitutional convention of the proposed American Geological Institute held in New York City October 22 and 23, 1944. His complete report was published in the February, 1945, *Bulletin*. The various organizations eligible for initial membership are now considering ratification of the proposed constitution. The principles of cooperation among organizations set out in the proposed constitution are believed to be sound.

During the year a diligent effort was made to keep abreast of developments in Washington, particularly of those relating to Selective Service, and to be of service to the governmental agencies. A second survey of the exploration personnel of the petroleum and natural gas industries was made, which survey indicated definitely that a manpower shortage still exists in exploration. The results of the survey were communicated to the Petroleum Administration for War, and were incorporated in "Report on Manpower in Production Branch of the Petroleum Industry," prepared by a special committee appointed by John M. Lovejoy, chairman, Manpower Committee, Petroleum Industry War

Council. In response to the request of the National Roster of Scientific and Specialized Personnel definitions of petroleum geology, surface geology and subsurface geology were prepared and furnished them.

All committees turned in a stellar performance during the year. All have accomplished their tasks with only minor aid from Association officers. Many were hampered in their work by the cancellation of their annual meetings. Read the committee reports published in the *Bulletin*, and you will come to realize the important part they play in the Association. I congratulate all of them on their fine work.

I regard the opportunity of serving geologists and geology through the presidency of the Association as the greatest privilege that can accrue to a geologist. It is also a pleasure, for in this live Association every member, associate, officer and member of the headquarters staff gladly assist the president in any way possible. During my term no member refused to help out when requested. The amount of hidden talent in this Association is enormous, and I only wish I had been cleverer in ferreting out and putting to work more of it. No member of the executive committee restricted his interest and activities to those of his particular office. The business manager and his headquarters staff continued to be most efficient and cooperative in a seemingly effortless way. Mr. Hull attended all six of the executive committee meetings, and gave freely of the wisdom acquired in his many years of Association experience.

I am looking forward to additional service to the Association in the capacity of past-president, and trust that the next president will impose upon me as I imposed upon past-president Denison. He had two misfortunes—living in the headquarters city and possessing unusual insight into Association affairs—and I could not resist the temptation to use both.

Lastly, I look forward to the return to peaceful pursuits of the 682 members and associates who are giving so much in the service of our country.

IRA H. CRAM, *president*

EXHIBIT II. REPORT OF SECRETARY-TREASURER

(Year ending March 1, 1945)

Membership.—It is gratifying to note that, in spite of the war, the Association membership continues to grow. Total membership is now (March 1) at an all-time high of

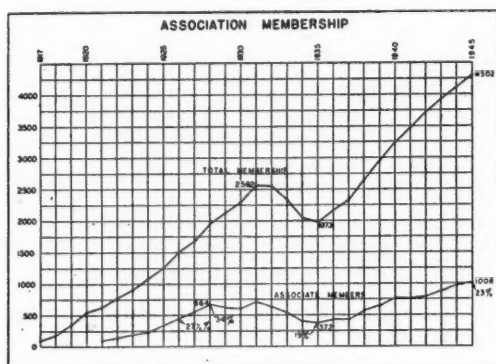


FIG. 1

4,326. During the year 303 new members and associates were added to the rolls and 86 were lost because of various reasons, making a total net-gain of 217. This is a greater increase than last year when the total net-gain was 186. At the present time the number of applications on hand is 135 compared to 98 in 1944.

There are now 682 of our members in the armed forces and many have taken advantage of the ruling in the by-laws which allows them to retain membership without the payment of annual dues. The total number thus retaining membership is 241.

Figure 1 is a chart showing the total Association membership since beginning. Except for the period of the depression, there has been a steady gain in membership. The lower line shows the number of associate members. There has been a feeling among some of our members that the number of associates was gradually becoming too high. It is pointed out, however, that the percentage at the present time is not excessive as compared to past years and that there is no decided trend toward an unbalanced membership.

During the year 21 of our members have passed away. Three of these were killed in line of duty in military service. The loss of these members will be keenly felt by the Association. They are as follows.

MEMBERS AND ASSOCIATES DECEASED

From March 1, 1944

Honorary—Taff, Joseph Alexander, March 10, 1944

Active—*Barnett, John F., Jr., October 13, 1944
 Bremner, Carl St. John, September 18, 1944
 Buehler, H. A., March 15, 1944
 Cuyler, Robert Hamilton, March 13, 1944
 Derden, Jesse Homer, June 16, 1944
 *Farish, Linn Markley, September 11, 1944
 Funk, Marion H., December 30, 1944
 Graham, David H., August 30, 1944
 Grogan, Samuel A., August 9, 1944
 Hager, Lee, August 11, 1944
 Henderson, Charles W., January 26, 1945
 Henny, Gerhard, September 9, 1944
 Luman, Edmondson D., December 9, 1944
 McCoy, Alex W., June 30, 1944
 Richards, George L., March 20, 1944
 Shoenfelt, Cecil Earl, April 17, 1944
 Van Sant, John Sigmund, May 3, 1944
 Winterer, Edward Virgil, March 14, 1944
 Wright, Harry Favill, April 15, 1944

Associate—*Newell, Donald Frost, December 7, 1944

* Killed in line of duty in military service.

REPORTED AS MISSING IN ACTION

Bachman, F. F., March, 1943
 Mueller, F. W., December 16, 1944

Tables I, II, and III¹ give data concerning total membership by years, comparative data of membership, and geographic distribution. (Actual listing of members by localities is given in the second section of the annually published membership list. See *March Bulletin*.)

Finances.—The usual annual audit by Arthur Young and Company was published in the March, 1945, *Bulletin* and may be inspected by any desiring details as to the financial condition of the Association. In order to simplify the data presented in that audit, the following tabulations have been prepared.

¹ Tables I to X immediately following secretary-treasurer's report give all pertinent data.

THE ASSOCIATION ROUND TABLE

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STATEMENT OF INCOME FOR 1944

(December 31, 1944)

Operating Income

Dues.....	\$37,992.00	
Interest and dividends.....	3,813.92	
Increase value investments.....	4,421.83	
Miscellaneous.....	997.16	
Income from publications.....	35,745.61	
TOTAL OPERATING INCOME.....	\$82,970.52	\$82,970.52

Expenses

Cost of publications.....	\$37,715.27	
General administration.....	19,070.14	
Convention (Dallas).....	811.85	
Research.....	420.00	
TOTAL EXPENSE.....	\$58,017.26	\$58,017.26

EXCESS INCOME OVER EXPENSE.....	\$24,953.26	
Donation to Sidney Powers Medal Fund.....	\$ 4,818.50	

TOTAL INCOME.....	\$29,771.76	
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It is interesting to note that revenue from dues (first line) is roughly equal to the cost of publications (first line under expenses), both being approximately \$38,000. Of this \$38,000, cost of publications, \$31,377 is for the *Bulletin*. This amount is 82 per cent of the revenue from dues. Thus, 82 per cent of money paid to the Association as dues is returned to members by the distribution of the *Bulletin*. The item, "Income from publications," amounting to \$35,745, is from advertising, sale of the *Bulletin* to non-members, and from sale of special publications.

Excess of income over expenses is \$24,953. With the non-recurring item of \$4,818—the donations to the Sidney Powers Medal Fund—the total net-income or profit is \$29,771.

Assets.—During the past year the Association has made several investments. We have purchased \$10,000 worth of Government bonds, \$3,000 worth of preferred stocks, and \$6,000 worth of common stocks. Our total assets are now at an all-time high of \$183,336.47.

ASSETS

(December 31, 1944)

Type	Market Value
U. S. Government bonds.....	\$ 49,300.00
Public Utility bonds.....	4,196.25
Railroad bonds.....	8,095.00
Preferred stock, industrial.....	10,253.75
Common stock, industrial.....	22,571.74
Public utility common stock.....	3,943.61
Bank and insurance common stock.....	2,900.00
Savings account.....	4,873.86
Total.....	\$106,134.21
Cash and inventory.....	\$ 77,232.26
Total assets.....	\$183,366.47

The item of cash and inventory amounting to \$77,232.26 contains approximately \$58,000 in cash. This is probably an excessive amount of cash to have on hand and it is the recommendation of the outgoing executive committee that additional stocks or bonds be purchased.

The afore-listed assets are divided into several funds.

THE ASSOCIATION ROUND TABLE

DIVISION OF ASSETS

(December 31, 1944)

Fund	Investments Market Value	Cash	Total
General Fund.....	\$ 71,550.90	\$ 48,591.84	\$120,142.74
Publication Fund.....	20,959.25	9,109.10	30,068.35
Research Fund.....	2,724.06	44.31	2,768.37
Life Membership Fund.....	1,600.00	200.00	1,800.00
Sidney Powers Medal Fund.....	9,300.00	297.57	9,597.57
Total Funds.....	\$106,134.21	\$ 58,242.82	\$164,377.03
Inventory (Publications, etc.).....			\$ 18,989.44
Total Cash, Investments, and Inventory.....			\$183,366.47

Note especially the \$30,000 in the Publication Fund. This item is large and reflects the fact that in the last few years we have not published any special volumes or other material requiring a large outlay of capital, while at the same time we have been selling items previously published and held as inventory. After the war this fund will be available for special publications now being considered or under preparation.

The Sidney Powers Memorial Medal Fund stands at \$9,597 invested in 2½ Government bonds. Part of the donations received have been issued to defray the cost of making the dies *et cetera*. From now on, only the income from this fund will be used.

COMPARISON OF 1942, 1943, 1944

	1942	1943	1944
Total assets (market value).....	\$119,755.91	\$140,119.75	\$183,366.47
Total income.....	65,262.18	64,465.00	82,970.52
Total expense.....	59,779.91	56,347.11	58,017.26
Profit or loss.....	+5,482.27	+8,117.89	+24,953.26
Membership.....	3,910	4,109	4,307

Comparisons may be odious but we point with pride to a comparison of our financial condition with years 1942 and 1943. Our total assets are now at an all-time high, being \$63,000 higher than in 1942. Also, our profit this year is \$19,000 greater than in 1942. (Note that for purposes of comparison, the Sidney Powers Medal Fund is not included in the profits for 1943 and 1944.) There are several reasons for this increase, including a greater revenue from advertising and sale of publications, more members paying dues, and an increase in dividends from investments.

This increase in income and assets is all very well but will it continue? Income from advertising amounted to \$16,500 last year. This may drop greatly after the war, though, of course, we can not be sure. Moreover, the value of our stocks and bonds may fall with a post-war market recession. For these and perhaps other reasons we should view our financial progress with a questioning mind and not be too optimistic in interpreting the future trend.

1945 budget.—Table X gives a tabulation of the estimated budget for 1945. With an estimated income of \$76,000, a total expenditure of \$56,000 is expected. Part of this expected income will be from the sale of the *Tectonic Map of the United States* now being distributed. Ample funds appear to be available for unforeseen exigencies.

Acknowledgments.—During two years as secretary-treasurer, I have come more and more to the realization that our business manager and his headquarters staff have been very successful in keeping the Association's affairs moving smoothly. They have handled, among other things, more than 40,000 pieces of mail *this year*, taken care of all business matters pertaining to publications, collected dues, maintained statistical files, and automatically carried out the hundreds of duties of their office. This has been done efficiently and accurately.

Finally, I have enjoyed my association with the members of the executive committees on which I have served. It has been a valuable experience and I recommend it to my successor.

ROBERT E. RETTGER, *secretary-treasurer*

TABLE I
TOTAL MEMBERSHIP BY YEARS

May 10, 1917.....	94	March 1, 1931.....	2,562
February 15, 1918.....	176	March 1, 1932.....	2,558
March 15, 1919.....	348	March 1, 1933.....	2,336
March 18, 1920.....	543	March 1, 1934.....	2,043
March 15, 1921.....	621	March 1, 1935.....	1,973
March 8, 1922.....	767	March 1, 1936.....	2,169
March 20, 1923.....	901	March 1, 1937.....	2,331
March 20, 1924.....	1,080	March 1, 1938.....	2,646
March 21, 1925.....	1,253	March 1, 1939.....	2,951
March 1, 1926.....	1,504	March 1, 1940.....	3,240
March 1, 1927.....	1,670	March 1, 1941.....	3,474
March 1, 1928.....	1,952	March 1, 1942.....	3,717
March 1, 1929.....	2,126	March 1, 1943.....	3,923
March 1, 1930.....	2,292	March 1, 1944.....	4,109
		March 1, 1945.....	4,326

TABLE II
COMPARATIVE DATA OF MEMBERSHIP

	March 1, 1944	March 1, 1945
Number of honorary members.....	12	12
Number of life members.....	7	9
Number of members.....	3,129	3,298
Number of associates.....	961	1,007
Total number of members and associates.....	4,109	4,326
Net increase in membership.....	186	217
Total new members and associates.....	246	250
Total reinstatements.....	51	53
Total new members and reinstatements.....	297	303
Applicants elected, dues unpaid.....	7	36
Applicants approved for publication.....	40	49
Recent applications.....	45	50
Total applications on hand.....	98	135
Applicants for reinstatement elected, dues unpaid.....	0	2
Recent applications for reinstatement.....	4	2
Total applications for reinstatement on hand.....	4	4
Applicants for transfer approved for publication.....	9	18
Recent applications for transfer on hand.....	13	14
Total applications for transfer on hand.....	22	32
Number of members and associates resigned.....	3	11
Number of members and associates dropped.....	89	55
Number of members and associates died.....	19	20
Total loss in membership.....	111	86
Total gain in membership.....	297	303
Number of members and associates in arrears, previous years.....	139	58
Members in arrears, current year.....	484	309
Associates in arrears, current year.....	169	134
Total number members and associates in arrears, current year.....	653	443
Total number members and associates in good standing.....	3,317	3,825

THE ASSOCIATION ROUND TABLE

TABLE III
GEOGRAPHIC DISTRIBUTION OF MEMBERS

March 1, 1945			
Alabama.....	15	Louisiana.....	228
Arizona.....	2	Maryland.....	12
Arkansas.....	20	Massachusetts.....	19
California.....	513	Michigan.....	49
Colorado.....	78	Minnesota.....	5
Connecticut.....	6	Mississippi.....	85
Delaware.....	2	Missouri.....	33
Dist. of Columbia.....	91	Montana.....	22
Florida.....	34	Nebraska.....	12
Georgia.....	4	Nevada.....	2
Illinois.....	100	New Hampshire.....	1
Indiana.....	56	New Jersey.....	9
Iowa.....	10	New Mexico.....	36
Kansas.....	176	New York.....	125
Kentucky.....	22	North Carolina.....	3
		North Dakota.....	2
Total members in United States.....		3,963	
Alberta.....	47	Egypt.....	10
Angola.....	1	England.....	15
Argentina.....	13	Germany.....	1
Australia.....	8	Gold Coast.....	1
Barbados.....	1	Haiti.....	1
Belgian Congo.....	1	Honduras.....	1
Bolivia.....	1	India.....	4
Brazil.....	2	Iraq.....	1
British Columbia.....	1	Mexico.....	16
British Guiana.....	1	Netherlands.....	1
Chile.....	7	New Brunswick.....	2
Colombia.....	56	New Zealand.....	5
Cuba.....	9	Nicaragua.....	2
Dominican Republic.....	2	Nova Scotia.....	1
Ecuador.....	13		
Total members in foreign countries.....		363	
Grand total.....		4,326	
		Ohio.....	27
		Oklahoma.....	580
		Oregon.....	4
		Pennsylvania.....	88
		Rhode Island.....	1
		South Carolina.....	2
		South Dakota.....	5
		Tennessee.....	9
		Texas.....	1,337
		Utah.....	10
		Virginia.....	15
		Washington.....	12
		West Virginia.....	21
		Wisconsin.....	10
		Wyoming.....	70
		Ontario.....	9
		Palestine.....	1
		Paraguay.....	1
		Persian Gulf.....	3
		Peru.....	12
		Prince Edward Is.....	1
		Quebec.....	1
		Saskatchewan.....	2
		Scotland.....	1
		Switzerland.....	1
		Syria.....	1
		Tasmania.....	1
		Trinidad.....	15
		Turkey.....	3
		Venezuela.....	87

THE ASSOCIATION ROUND TABLE

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TABLE IV

COMPARISON OF ACCRUED INCOME BY CALENDAR YEARS

	1942	1943	1944
<i>Dues</i>			
Members.....	\$30,270.00	\$30,320.00	\$31,540.00
Associates.....	5,624.00	6,096.00	6,452.00
Total.....	\$35,894.00	\$36,416.00	\$37,992.00
<i>Bulletin</i>			
Subscriptions.....	\$ 3,937.22	\$ 4,125.10	\$ 5,160.46
Advertising.....	8,168.10	8,728.54	10,507.39
Total.....	\$12,105.32	\$12,853.64	\$21,667.85
<i>Back Numbers, etc.</i>			
Bound Volumes of Bulletin.....	\$ 2,152.90	\$ 2,859.20	\$ 3,389.00
Back Numbers of Bulletin.....	556.99	1,448.46	2,160.68
Other Publications.....	129.94	117.16	274.86
Total.....	\$ 2,839.83	\$ 4,424.82	\$ 5,824.54
<i>Special Publications</i>			
Geology of Natural Gas*.....	\$ 372.60	\$ 592.62	\$ 616.00
Geology of Tampico Region*.....	146.35	257.10	228.65
Gulf Coast Oil Fields*.....	245.60	343.63	441.80
Map of Southern California*.....	21.85	30.85	26.80
Miocene Stratigraphy of California*.....	138.10	206.50	255.50
Recent Marine Sediments*.....	105.10	63.00	—
Stratigraphic Type Oil Fields*.....	3,504.93	1,296.01	1,205.12
Source Beds of Petroleum*.....	1,746.65	692.97	692.20
Possible Future Oil Provinces.....	571.23	328.24	426.77
Origin of Oil.....	312.00	120.90	25.00
Permian of W. Texas and SE. New Mexico.....	257.45	445.70	108.60
Petroleum Discovery Methods.....	573.00	340.00	253.80
Sedimentation.....	240.00	293.50	8.00
Tectonic Map of United States.....	—	—	765.50
Total.....	\$ 8,234.86	\$ 5,011.02	\$ 5,053.74
<i>Other Income</i>			
Delinquent Dues Charged Off.....	\$ 378.00	\$ 360.00	\$ 708.00
Interest, General Fund.....	2,015.16	1,793.68	3,025.25
Interest, Publication Fund.....	540.06	518.72	600.77
Interest, Research Fund.....	74.06	60.15	59.56
Interest, Powers Medal Fund.....	—	—	168.34
Profit, sale of Investments, General Fund.....	60.41	—	4.82
Miscellaneous.....	85.83	155.88	196.11
Sale of Library.....	17.50	17.50	6.00
Members Reinstated.....	32.50	49.75	42.23
Adjustment of stated value of Investments to lower or Cost or Market.....	2,951.55	2,760.39	4,421.83
Regional Cross Sections.....	27.10	43.45	30.80
Inventory Increase.....	6,227.93	—	3,168.68
Donations, Powers Medal Fund.....	—	5,290.50	4,818.50
Total.....	\$71,490.11	\$69,761.50	\$87,789.02

* Income of Publication Fund.

THE ASSOCIATION ROUND TABLE

TABLE V

COMPARISON OF ACCRUED EXPENSES BY YEARS

<i>General and Administrative Expenses</i>	1942	1943	1944
Salaries—Manager.....	\$ 3,750.00	\$ 4,250.00	\$ 3,750.00
Clerical.....	5,104.80	5,353.45	6,400.80
Payroll Taxes (including penalty and interest).....	4,484.87	422.10	469.81
Rent.....	1,620.00	1,674.00	1,782.00
Telephone and Telegraph.....	367.27	304.09	306.72
Postage.....	1,812.98	2,043.95	2,014.31
Office Supplies and Expenses.....	304.16	564.22	459.64
Printing and Stationery.....	405.64	673.04	624.99
Audit Expense.....	300.00	300.00	300.00
Insurance.....	237.11	239.29	164.11
Convention Expense (Net).....	677.25	350.41	811.85
Freight and Express.....	229.38	270.39	213.59
Bad Debts.....	922.50	1,002.23	346.07
Miscellaneous.....	296.46	227.08	287.94
Depreciation—Furniture and Fixtures.....	53.35	111.33	—
Investment Counsel.....	400.00	400.00	400.00
Traveling Expenses.....	140.09	205.74	270.88
Bass-Neumann Oil Analysis Project ¹	—	—	320.00
Van Tuyl-Parker Migration-Accumulation Project ¹	—	—	50.00
Tectonic Map of United States ¹	188.71	975.75	50.00
Review of Petroleum Geology in 1943 ¹	—	—	343.75
Donation—Soc. of Econ. Paleon. and Mineralogists.....	—	1,500.00	—
Distinguished Lecture Committee.....	500.00	500.00	—
National Service Committee.....	652.26	364.62	190.40
Geological Institute of America.....	—	327.50	59.36
Dies and Cast for Powers Medal.....	—	—	685.77
Total.....	\$22,536.83	\$22,059.19	\$20,301.99
<i>Publication Expenses</i>			
Salaries—Manager.....	\$ 3,750.00	\$ 3,750.00	\$ 3,750.00
Editorial.....	4,013.23	3,980.50	4,251.29
Printing Bulletin.....	17,753.64	16,328.20	19,195.74
Engravings.....	2,800.37	1,932.69	2,113.05
Separates.....	455.91	161.88	186.33
Stencils and Mailing.....	252.81	350.67	359.22
Binding Bulletins.....	578.62	623.05	597.69
Postage and Express (Bulletins).....	977.98	765.36	852.69
Copyright Fees.....	24.00	24.00	24.00
Freight, Express, Postage (Other Publications).....	188.71	92.82	102.92
Discounts.....	3.11	—	—
Miscellaneous.....	59.75	50.38	241.22
Special Publications.....	12,597.15	637.76	6,012.55
Special Publication Inventory Decrease.....	—	5,546.08	—
Regional Cross Sections.....	15.73	44.53	28.57
Total.....	\$43,471.01	\$34,287.92	\$37,715.27
Total Expense.....	\$66,007.84	\$56,347.11	\$58,017.26

¹ Research Fund Project.

THE ASSOCIATION ROUND TABLE

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TABLE VI
COMPARISON OF NET INCOME BY YEARS

	1942	1943	1944
Accrued Income.....	\$71,490.11	\$69,761.50	\$87,789.02
Expenses			
General and Administrative.....	22,536.83	22,059.19	20,301.99
Publication.....	43,471.01	34,287.92	37,715.27
Total.....	\$66,007.84	\$56,347.11	\$58,017.26
Excess Income over Expenses.....	5,482.27	13,414.39	29,771.76

TABLE VII
INVESTMENTS

	Cost	Market Value End of Year
1942 Values		
General Fund.....	\$ 62,272.48	\$ 56,717.53
Publication Fund.....	16,671.45	15,194.18
Research Fund.....	2,485.70	2,335.70
Total.....	\$ 81,429.63	\$ 74,247.41
1943 Values		
General Fund.....	\$ 63,625.03	\$ 60,282.23
Publication Fund.....	16,622.40	15,544.62
Research Fund.....	2,545.85	2,544.60
Total.....	\$ 82,793.28	\$ 78,371.45
1944 Values		
General Fund.....	\$ 72,346.42	\$ 71,550.90
Publication Fund.....	21,456.99	20,959.25
Research Fund.....	2,606.56	2,724.06
Sidney Powers Memorial Medal Fund.....	9,300.00	9,300.00
Life Membership Fund.....	1,600.00	1,600.00
Total.....	\$107,309.97	\$106,134.21

TABLE VIII
COMPARISON OF COST OF BULLETIN

	1942	1943	1944
Total Expenses.....	\$30,651.31	\$27,958.98	\$31,377.35
Monthly Edition.....	5,000	5,000	5,300
Total Copies Printed.....	60,000	60,000	63,600
Total Pages Printed, including Covers.....	2,315	2,118	2,354
Total Pages of Text.....	1,893	1,674	1,810
Total Cost per Copy.....	\$ 0.511	\$ 0.465	\$ 0.49

THE ASSOCIATION ROUND TABLE

TABLE IX

(Section 1)

SPECIAL PUBLICATIONS

	<i>Geology Natural Gas (1935)</i>	<i>Geology Tampico Region (1936)</i>	<i>Gulf Coast Oil Fields (1936)</i>	<i>Tectonic Map of California (1936)</i>	<i>Total</i>
Inventory					
Dec. 31, 1943.....	\$1,080.00	\$1,288.27	\$ 568.62	\$ 34.72	\$2,971.61
Dec. 31, 1944.....	468.00	1,209.12	319.41	30.40	2,026.93
Sales.....	616.00	228.65	441.80	26.80	1,313.25
Total Edition.....	2,500	1,575	2,510	940	
Copies on Hand					
Dec. 31, 1943.....	270	563	324	434	
Dec. 31, 1944.....	117	528	182	380	
Number of Pages.....	1,227	280	1,070	—	
Cost (inventory) per Copy.	\$ 4.00	\$ 2.29	\$ 1.755	\$ 0.08	
Selling Price					
Members and Associates.	4.50	3.50	3.00	0.50	
Non-Members.....	6.00	4.50	4.00	0.50	

TABLE IX

(Section 2)

SPECIAL PUBLICATIONS

	<i>Miocene Stratigraphy of California (1938)</i>	<i>Stratigraphic Type Oil Fields (1942)</i>	<i>Source Beds of Petroleum (1942)</i>	<i>Tectonic Map of U. S. (1944)</i>	<i>Total</i>
Inventory					
Dec. 31, 1943.....	\$1,898.32	\$3,245.30	\$1,467.55	\$ —	\$ 6,611.17
Dec. 31, 1944.....	1,757.25	2,457.96	1,102.50	5,697.54	11,015.25
Sales.....	255.50	1,205.12	692.20	765.50	2,918.32
Total Edition.....	1,530	2,526	1,539	5,000	
Copies on Hand					
Dec. 31, 1943.....	767	1,150	599	—	
Dec. 31, 1944.....	710	871	450	4,569	
Number of Pages.....	450	902	566	—	
Cost (inventory) per Copy.	\$ 2.475	\$ 2.822	\$ 2.45	\$ 1.247	
Selling Price					
Members and Associates.	4.50	4.50	3.50	1.75	
Non-Members.....	5.00	5.50	4.50	1.75	

TABLE IX

(Section 3)

SPECIAL PUBLICATIONS

	<i>Origin of Oil (1941)</i>	<i>Petroleum Discovery Methods (1942)</i>	<i>Sedimen- tation (1942)</i>	<i>West Texas New Mexico Symposium (1942)</i>	<i>Possible Future Oil Provinces (1941)</i>	<i>Total</i>
Inventory						
Dec. 31, 1943.....	\$ 70.69	\$ 290.93	\$ 32.34	\$131.07	\$ 1.21	\$526.24
Dec. 31, 1944.....	56.24	77.26	26.69	11.43	246.23	417.85
Sales.....	25.00	253.80	8.00	108.60	426.77	822.17
Total Edition.....	905	1,500	1,208	521	3,052*	
Copies on Hand						
Dec. 31, 1943.....	137	418	103	172	3	
Dec. 31, 1944.....	109	111	85	15	611	
Number of Pages.....	81	164	68	231	154	
Cost (inventory) per Copy	\$ 0.516	\$ 0.696	\$ 0.314	\$ 0.762	\$ 0.403	
Selling Price						
Members and Associates.	1.00	1.00	0.50	1.50	1.00	
Non-Members.....	1.00	1.00	0.50	2.00	1.50	

* 1,000 copies printed in 1945.

TABLE X
BUDGET

	1944	1945 Est.
REVENUE		
<i>Dues</i>		
Members.....	31,540	32,000
Associates.....	6,452	7,000
Reinstatements and Delinquents.....	750	700
	38,742	39,700
<i>Bulletin</i>		
Subscriptions.....	5,160	5,000
Advertising.....	16,507	14,000
Bound Volumes.....	3,389	3,000
Back Numbers.....	2,160	1,800
	27,216	23,800
<i>Special Publications</i>		
Geology of Natural Gas.....	616	500
Geology of Tampico Region, Mexico.....	228	200
Gulf Coast Oil Fields.....	441	300
Tectonic Map of California.....	26	25
Miocene Stratigraphy of California.....	255	220
Recent Marine Sediments.....	—	—
West Texas Regional Sections.....	30	25
Stratigraphic Type Oil Fields.....	1,205	1,000
Source Beds of Petroleum.....	692	500
Possible Future Oil Provinces.....	426	400
Origin of Oil.....	25	25
Oil-Discovery Methods.....	253	100
Permian of West Texas and Southeastern New Mexico.....	108	—
Tectonic Map of United States.....	765	5,000
Sedimentation.....	8	5
	5,078	8,300
<i>Other Income</i>		
Investments.....	4,566	4,000
Convention (net).....	—	—
Miscellaneous.....	477	300
Powers Medal Fund Donations.....	4,818	—
	9,861	4,300
TOTAL REVENUE.....	80,897	76,100
EXPENSE		
<i>General and Administrative</i>		
Salaries.....	10,150	10,500
Rent.....	1,782	1,800
Telephone and Telegraph; Postage.....	2,321	2,350
Audit.....	300	300
Investment Counsel.....	400	400
Insurance; Taxes.....	634	675
Bad Debts.....	346	500
Convention (net).....	812	300
Office Supplies, Misc.....	1,857	1,950
Oil Analysis Research.....	320	—
Migration and Accumulation.....	34	135
Review of Petroleum Geology.....	476	135
National Service Committee.....	190	100
"American Geological Institute".....	59	75
Powers Medal.....	685	250
President's Award.....	—	100
	\$20,366	\$21,100

TABLE X—Continued

	1944	1945 Est.
<i>Bulletin Publication</i>		
Salaries.....	8,001	8,000
Printing.....	19,195	19,000
Engraving.....	2,113	2,200
Separates.....	186	200
Cloth Binding.....	597	600
Postage and Express.....	852	900
Miscellaneous.....	600	600
	<hr/> \$31,544	<hr/> \$32,500
<i>Special Publications</i>		
Oil Provinces.....	429	—
W. Texas Regional Sections.....	28	25
Tectonic Map of the United States.....	4,946	—
Permian Symposium.....	—	500
Comprehensive Index (salaries and supplies).....	636	2,000
Miscellaneous.....	—	1,500
Freight, Express, Postage.....	102	900
	<hr/> \$ 6,141	<hr/> \$ 4,925
TOTAL EXPENSE.....	<hr/> \$58,051	<hr/> \$56,025

EXHIBIT III. REPORT OF EDITOR

When Ralph Waldo Emerson once said, "What you are speaks so loud I cannot hear what you say," he might have been addressing an editor, for what an editor has been and what he has done far transcends in importance—or in infamy—anything he may say in a report. In reviewing the course of his work he has no need to pass in review his errors of commission and omission. His critics will do that for him. He can only extol the excellence of his product, and for that the contributors, the associate editors, the committee for publication, and the headquarters staff share the responsibility and the work. To them high credit is due.

In spite of the fact that a good *Bulletin* is the editor's best and truest report, it is both customary and fitting that a general statement regarding editorial policies and the status of its publications be made to this great membership at least once a year.

As your editor of the past year I have had no pet policies to establish and no revolutionary reforms to suggest. It is fortunate that such is the case because the times are not propitious for such changes even if they were deemed desirable. It has been my hope, rather, to direct the editorial work of the *Bulletin* in the tried and true methods so efficiently employed by my illustrious predecessors. The impact of the war on the work of the *Bulletin* staff and contributors has been such that our ingenuity has been taxed to the utmost to maintain the present high standards; and this could not have been done except for the most sincere cooperation and aid of all our members.

You must all be aware of the decreased size of the *Bulletin* and of the inferior quality of the paper upon which we are forced to print it. The smaller size results not from a fewer number of printed pages, for we have printed more pages than in the two preceding years, but from the much lighter paper stock. The light paper mars the effect of the printed page and does not adequately reproduce many of our illustrations. We shall want to improve this state of affairs as soon as conditions permit. You will be interested to know, however, that our paper stock is deemed more than adequate in quantity for our needs during the current year.

In spite of the restrictions of time, travel, and facilities under which everyone must work these days, we have been able to publish a full volume of scientific papers of rather

general interest. We have lived (and are still living) under the constant fear that we should not have enough papers to print a *Bulletin* of normal size. Happily, this situation has never quite come to pass, thanks to the diligent effort of all of us. We have not, however, always had enough papers in reserve to enable us to formulate the balanced type of subject matter arrangement most desirable; and while the reserve of papers for the current volume of the *Bulletin* is distressingly small, there is every reason to believe that it will be possible to make Volume 29 about normal size.

You will note from the secretary's figures that the cost of publishing the *Bulletin* is slightly above last year, but the edition is larger by 300 and the number of printed pages is somewhat greater. During 1944 the *Bulletin* contained a total of 87 papers, 56 of which were "major articles" and 31 were "geological notes" or "discussions." These are exclusive of the reviews and reports appearing in several of the numbers.

You are all familiar with the general organization of the *Bulletin* into its various sections. I wish to call particular attention to the "Discussion" section. It is my feeling that we are not making the fullest use of this part of our publication. There must be many statements made in the various articles which are either erroneous or not in accord with the opinions of many of the members. Attention should be called to the errors and other opinions should be fully expressed. The Discussion section of the *Bulletin* is for this purpose, and it is hoped that the members will make increasing use of it.

Following the precedent of my predecessors, I have brought down to date the data on the number, types, and sources of articles appearing in the *Bulletin*, and this is indicated in Table I.

TABLE I
SOURCE OF BULLETIN PAPERS

Year	Total Papers	Convention Papers	Non- Convention Papers	Oil- Company Authors	Consulting Authors	Others*
1937	83	34	39	45	14	25
1938	92	49	27	41	16	34
1939	108	48	28	53	15	40
1940	112	44	35	53	22	37
1941	119	50	44	47	19	53
1942	72	30	42	28	13	31
1943	74	34	40	30	8	36
1944	87	27	60	52	9	26

* University, Federal, and State geological survey sources, in 1944, divided as follows: Universities—20, Federal surveys—9, State surveys—7.

The considerable decrease in the number of papers originating in the annual meeting continues a trend that has been developing since 1941. This trend, of course, is destined to hit an absolute bottom in 1945. There is, on the other hand, a noticeable and commendable increase in papers written by oil-company authors.

You have seen inaugurated this year the President's Award given to the young author of the most outstanding contribution to petroleum geology published in the *Bulletin* each year. It is hoped and believed that this award for excellence will be a powerful stimulus to our young authors to produce more and better contributions down through the years. Rodger Denison, chairman, and the members of the medal award committee are to be commended for the effective way in which they have set up the machinery for selection of the papers and for making the award.

Your executive committee has carefully considered the many problems of publication and has, it appears, taken some important steps which will contribute substantially to the vast printed record of the Association's activities. Some of the more important of these are as follows.

1. The decision has been taken to begin compiling a comprehensive index of the Association's publications from 1917 to 1945. This work is in progress and is now well advanced. Such a task is great, but it is hoped that the Index will be ready late in 1946.

2. So many requests have come in for copies of the exhausted edition of the special publication, "Possible Future Oil Provinces of the United States and Canada," that it was thought wise to reprint it. This has been done, and sales of the publication are satisfactory.

3. The Association has long supported and sponsored the preparation of the new *Tectonic Map of the United States*, prepared under the direction of the committee on tectonics, Division of Geology and Geography of the National Research Council. The monumental result of this coöperative effort is now complete, and distribution of the map is in progress.

4. It was felt that the significant paper by Frank B. Notestein, Carl W. Hubman, and James W. Bowler entitled "Geology of the Barco Concession, Republic of Colombia, South America," published in the *Bulletin* of the Geological Society of America, would be of such interest to the petroleum industry that it should be made available to the Association membership. Accordingly, the executive committee arranged for a reprint of 500 copies of the paper and these are being distributed at a nominal cost.

5. The Association has tried by all means at its command to keep in touch with its men in the Service, and to help them in so far as possible to keep abreast of geological happenings. To this end, and following the happy suggestion of John Ferguson, copies of Van Tuyl's "Review of Petroleum Geology for 1943" were sent free of charge to all members of the Association in the Service. In this connection it is most regrettable that Professor Van Tuyl finds that conditions no longer permit him to carry on the very useful work of preparing these reports; and the Association has not yet been able to work out a plan whereby it may be done.

6. Meantime, the executive committee, the editorial board, and others interested in the Association's publications have discussed at length the feasibility of bringing about additional special publications to add to our already impressive list. Progress in these efforts has of necessity been slow and uncertain. There is, however, the possibility that we may be able to put out a volume on the *Geology of the Oil Fields of Venezuela* and a third volume to add to the two-volume set of *Structure of Typical American Oil Fields*. Plans for the Venezuelan volume are already far advanced; and while the likelihood of getting the material together for the structural volume now seems rather remote, there is good reason to believe that it will be done.

Our general editorial routine for the *Bulletin* and for other publications is, I believe, one of the most completely organized and competent of any scientific group. Many of our associate editors have performed their functions for the *Bulletin* through many volumes. Meantime, enough new members have from time to time been added to the editorial staff to assure a continuous flow of fresh ideas, and the Association has been most fortunate in its selection of special editors for special publications. All are men of trained and scholarly mind, thoroughly experienced in the art of separating that which is important from that which is trivial. The active and efficient committee on publications under the enthusiastic chairmanship of J. V. Howell has reduced the problem of the development papers to a well organized routine and has aided the *Bulletin* in many other ways. Finally, the business manager, in the richness of his experience and devotion to his task, has, together with efficient staff, been diligent to see that no stone is left unturned to make the *Bulletin* appear to its best advantage.

As a result of the efforts of all concerned, few if any technical periodicals receive more careful prepublication scrutiny, have a format more inviting to the reader, or appear with fewer errors.

GAYLE SCOTT, editor

EXHIBIT IV. REPORT OF RESOLUTIONS COMMITTEE

On the occasion of this the 30th annual meeting of the American Association of Petroleum Geologists, be it resolved that we express our sincere thanks to all who have contributed to making possible our third wartime meeting, and especially to:

1. The Tulsa Geological Society and its president, J. V. Howell,
2. To J. P. D. Hull, representing our headquarters staff,
3. To A. Rodger Denison, representing the executive committee,
4. To the Mayo Hotel and its management for adequate accommodations for our meetings, and
5. To the Tulsa Club for making available its facilities for the dinner sponsored by the Tulsa Geological Society.

We further express our appreciation to members and all committees who have during the past year so successfully carried on the necessary functions of our Association under wartime conditions. In conclusion we send greetings and all good wishes to our members serving in the armed forces.

W. B. WILSON, *chairman*

EXHIBIT V. RECOMMENDATIONS OF BUSINESS COMMITTEE

The business committee recommends to the annual business meeting that the following proposals be adopted.

- I. The executive committee recommends and the business committee has approved the following changes in the by-laws.

Change the by-laws, Article VI, Section 1, first paragraph, to read as follows:

"There shall be the following standing committees: business committee; research committee; committee on geologic names and correlations; committee on applications of geology; committee for publication; finance committee; *committee on statistics of exploratory drilling*; trustees of revolving publication fund; trustees of research fund; and medal award committee."

Add new Section 12 under Article VI of by-laws as follows.

Committee on Statistics of Exploratory Drilling

"SECTION 12. The function of the committee on statistics of exploratory drilling shall be to assemble and compile statistics on the methods used to locate exploratory wells and on the results of exploratory drilling for oil and gas, and annually to submit for publication in the *Bulletin* a report summarizing and analyzing these data. This committee shall consist of 24 members unless a different number is authorized by the executive committee."

- II. The business committee recommends that the reports of the standing and special committees which were read and approved in the business committee meeting be approved and published in the *Bulletin*.

ROBERT E. RETTGER, *secretary*
GEORGE S. BUCHANAN, *chairman*

EXHIBIT VI. REPORT OF COMMITTEE ON CODE OF ETHICS
(Published in January *Bulletin*, pp. 117-18)

EXHIBIT VII. REPORT OF COMMITTEE ON METHOD OF ELECTION OF OFFICERS

This is the final report of the committee on method of election of officers which was appointed to comply with a recommendation of the Association's business committee at its March, 1944, meeting, as follows.

"5. The business committee recommends that the executive committee appoint a special committee to study, prepare, and present a method of election of officers by mail ballot, together with the necessary machinery for the counting of ballots. The method of election so formulated is to be presented for consideration at the business committee meeting in 1945. Said special committee shall file their report with the executive committee by December 1, 1944, and the executive committee shall send a copy of such report to all district representatives of the A.A.P.G. and to the presidents of the affiliated local societies by January 1, 1945."

This special committee was appointed because some local districts, through their business representatives, had requested that the present method of election be changed so that members who could not attend the annual meeting would be able to share in the election by some form of mailed ballot.

In previous years, two other special committees have been appointed to determine whether or not the system of election should be changed. The first of these committees recommended in 1940 that the method of election not be changed, and its recommendation was approved. The next committee recommended in 1941 a changed method of election, but its recommendation was rejected by the business committee.

The present committee was appointed not to recommend whether or not the method of election should be changed, but to investigate and determine the best method of election by mailed ballot if the members of the Association decide they want a mailed ballot. To accomplish this the committee has reviewed the files of all previous committees, has discussed the problem with as many members of the Association as possible, has corresponded extensively, and has met together once at Fort Worth on August 28 with five of the seven committee members in attendance. The committee has now agreed on the following procedure as the one best suited to the Association's needs, if the members decide to change the present method of election. After agreeing to recommend this procedure of election by mailed ballot the committee members have informally contacted representatives of many of the local districts to give them opportunity to consider the recommendation in advance. The replies appear to indicate that the proposed method may be satisfactory to those desiring a mailed ballot.

PROPOSED METHOD OF ELECTION BY MAILED BALLOT

Under the existing method, all nominations, balloting, and installation of new officers occur during the annual meeting. If a mailed ballot is used, the balloting must take place either before the annual meeting, which would force a changed method of nominations, or after the annual meeting, which would prevent the installation of new officers at the annual meeting. This committee has agreed that it will be better to have the nominations and mailed ballot before the annual meeting so the incoming officers can be installed during the meeting. The recommended procedure to accomplish this would be as follows.

1. *Nominating committee.*—A nominating committee of five (four members and a chairman) will be selected each year by the Association's business committee during the annual meeting in March or April. This nominating committee will serve one year and will nominate one or more candidates for each elective office of the Association. Since the business committee is largely composed of representatives elected by local districts of Association members, their selections for the nominating committee should represent the majority of Association members.

2. *Publication of nominations.*—The nominating committee will publish in the October *Bulletin* its slate of one or more candidates for each office.

3. *Additional nominations by petition.*—After the nominating committee publishes its slate in the October *Bulletin*, additional nominations can be made by written petition of twenty-five, or more, members in good standing received at the Association headquarters not later than November 30.

4. *Preparation of ballot.*—Immediately after November 30, the Association headquarters will print a mailed ballot form, listing all those nominated, both by the nominating

committee and by petition; a blank line will also be provided under each office for write-in votes for any other members not nominated.

5. *Mailed ballot.*—As soon as possible after December 1, the Association headquarters will mail one printed ballot to each Association member providing special envelopes or other methods so it can be returned as a secret ballot. Mr. Hull, the business manager, estimates that postage for one mailed ballot will amount to about \$200, including airmail postage to members in foreign countries.

6. *Return of ballots.*—Ballots will be returned to Association headquarters where they will be placed unopened and secret in a locked ballot box, and all ballots received up to and including January 31 will be counted in the election. It has been suggested that the two months provided for the return of ballots may not be enough for members in foreign countries and three months was suggested, but the majority of the committee believes that with airmail two months will be sufficient.

7. *Counting of ballots and announcement of results.*—Immediately after January 31, a special election or ballot committee appointed by the president (which is the procedure at present) will open the ballot box, count the ballots, advise the president regarding the result, and officially announce the result at the annual meeting. It is assumed that the president may immediately announce the result through the press and news services.

8. *Run-off ballot.*—If more than two candidates are nominated for any of the offices, it is probable that some offices will not be filled by majority vote, and it will then be necessary to have a run-off election for the two candidates receiving the greatest number of votes in the first balloting. It is provided that if a run-off election is necessary, the Association headquarters will print and mail the necessary ballots by February 7, in which case the postage will again cost \$200.

9. *Return and counting of run-off ballots.*—The run-off ballots will be returned and handled in the same manner as the first ballots, and the time for return of the ballots will extend until one week before the annual meeting, which will provide 40 to 60 days, depending on when the meeting is held. The ballots will be counted and the results announced by the election or ballot committee previously appointed.

AMENDMENTS TO CONSTITUTION AND BY-LAWS

If this proposed plan is approved by the business committee and by the Association in its annual meeting, it will be necessary to amend the constitution and by-laws as follows. (The capitalized type indicates the changed part and the small type is the present wording.)

CONSTITUTION

Article IV

SECTION 2. The officers shall be elected annually from the Association at large by MEANS OF SECRET MAILED BALLOT IN THE FOLLOWING MANNER: THE NOMINATING COMMITTEE ELECTED BY THE BUSINESS COMMITTEE, AS PROVIDED IN THE BY-LAWS, SHALL NOMINATE ONE OR MORE CANDIDATES FOR EACH OFFICE, AND ITS NOMINATION SHALL BE PUBLISHED IN THE OCTOBER BULLETIN. ADDITIONAL NOMINATIONS MAY BE MADE BY WRITTEN PETITION OF TWENTY-FIVE, OR MORE, MEMBERS IN GOOD STANDING RECEIVED AT ASSOCIATION HEADQUARTERS NOT LATER THAN NOVEMBER 30. THE ASSOCIATION SHALL THEN PREPARE A PRINTED BALLOT, LISTING THE CANDIDATES FOR EACH OFFICE AND PROVIDING BLANK LINES FOR VOTES FOR ANY MEMBERS NOT NOMINATED, AND ONE BALLOT SHALL BE MAILED TO EACH MEMBER AS SOON AFTER DECEMBER 1 AS POSSIBLE. BALLOTS RETURNED TO ASSOCIATION HEADQUARTERS ON OR BEFORE JANUARY 31 SHALL BE PLACED AS RECEIVED IN A LOCKED BALLOT BOX AND SUBSEQUENTLY COUNTED BY A BALLOT COMMITTEE APPOINTED BY THE PRESIDENT. IF NO ONE OF THE CANDIDATES FOR ANY OFFICE RECEIVES A MAJORITY OF THE VOTES CAST FOR THAT OFFICE, A SECOND MAILED BALLOTING BETWEEN THE TWO RECEIVING THE HIGHEST NUMBER OF VOTES SHALL BE HELD. SUCH SECOND BALLOT SHALL BE MAILED TO THE MEMBERS NOT LATER THAN NOVEMBER 7, AND SHALL BE HANDLED

IN THE SAME MANNER AS THE FIRST BALLOT, AND SHALL BE COMPLETED ONE WEEK BEFORE THE PUBLISHED DATE OF THE ANNUAL MEETING. THE BALLOT COMMITTEE SHALL REPORT THE FINAL RESULTS TO THE PRESIDENT. BALLOTS OF DELINQUENT MEMBERS SHALL NOT BE COUNTED. IN CASE OF A TIE VOTE, THE EXECUTIVE COMMITTEE SHALL CAST ONE ADDITIONAL DECIDING VOTE. NO MEMBER CAN SIMULTANEOUSLY BE A NOMINEE FOR MORE THAN ONE OFFICE. Each candidate, when voted for as a candidate for the particular office for which he is nominated, shall be thereby automatically voted for as a candidate for the executive committee for one year, except that candidates for the presidency shall be automatically voted for as candidates for the executive committee for two years.

SECTION 4. The president shall be the presiding officer at all meetings of the Association, shall take cognizance of the acts of the Association and of its officers, shall appoint such committees as are required for the purposes of the Association, EXCEPT THE NOMINATING COMMITTEE, and shall delegate members to represent the Association. He may, at his option, serve on and be chairman of any committee, EXCEPT THE NOMINATING COMMITTEE.

SECTION 8. The officers shall assume the duties of their respective offices immediately after the annual meeting, WHICH FOLLOWS THEIR ELECTION.

Article VI. Meetings

The Association shall hold at least one stated meeting each year, which shall be the annual meeting. This meeting shall be held in March or in April at a time and place designated by the executive committee. At this meeting the election of members shall be announced, the proceedings of the preceding meeting shall be read, Association business shall be transacted, scientific papers shall be read and discussed and officers for the ensuing year shall be ANNOUNCED.

BY-LAWS

Article VI

Business Committee

SECTION 2. The business committee shall act as a council and advisory board to the executive committee and the Association. This committee shall consist of the executive committee, not more than five members at large appointed annually by the president, two members elected by and from each technical division, and the district representatives. The president shall also appoint annually a chairman and a vice-chairman, but neither of these need be one of those otherwise constituting the business committee. The secretary-treasurer shall act as secretary of the business committee. If a district or technical representative is unable to be present at any meeting of the committee he may designate an alternate, who, in the case of a district representative, may or may not be a resident of the district he is asked to represent, and the alternate, on presentation of such a designation in writing, shall have the same powers and privileges as a regularly chosen representative. The business committee shall meet the day before the annual meeting at which all proposed changes in the constitution or by-laws shall be considered, all old and new business shall be discussed, (and) recommendations shall be voted for presentation at the annual meeting, AND THE NOMINATING COMMITTEE AND THE CHAIRMAN THEREOF SHALL BE ELECTED.

NOMINATING COMMITTEE

SECTION 12. THE PURPOSE OF THE NOMINATING COMMITTEE IS TO NOMINATE CANDIDATES FOR ASSOCIATION OFFICES AS PROVIDED IN THE CONSTITUTION. THE COMMITTEE SHALL CONSIST OF FIVE MEMBERS TO SERVE ONE YEAR.

JOHN G. BARTRAM, *chairman*
RONALD K. DEFORD
W. DOW HAMM
JOHN S. IVY

HUGH D. MISER
C. L. MOODY
EARL B. NOBLE

EXHIBIT VIII. REPORT OF NATIONAL SERVICE COMMITTEE

In the first half of 1944 the national service committee learned that the Armed Forces were making some requests for geologists to develop information in and near certain of the fighting fronts. The requests were being made of, and were met by, established Government agencies. We felt that it was appropriate for the Fighting Services to turn to official sources for their geological needs, and that we should make no move that might delay or interfere with the procedure. The Government civilian agencies involved knew of the existence of the national service committee and of the information available regarding geologists in service. In the absence of any request for help in supplying the desired personnel we have assumed such help was not needed. It would have been desirable had we been informed, unofficially, of this activity if only to insure against interference by some inadvertent act on our part. Collisions are best avoided by appropriate signals. However, since we learned of what was going on, no harm was done.

We understand that most, if not all, of the geologists who were sent out had civilian status. This may have been advantageous, although we deprecate the assignment of civilian geologists to military work when there are so many fine geologists in uniform. We have no criticism of the ability of the men who were selected. Our only question is whether as strong an effort as possible was made to persuade the Military to use geologists already in the armed forces.

Contact was made with the Army Technical Detachment headed by Dr. Marsh White. We understand that this unit is still proceeding cautiously, feeling its way to make sure that it functions effectively and within the pattern set by military procedure. It is our impression that only by frequent visits to Washington can we be in a position to learn of and meet the needs for geologists that may be uncovered by this agency. As in many other activities we find ourselves handicapped by the lack of a full-time contact man in Washington.

The increasing number of geologists who have been released from military service calls for the creation of a service for securing and recording the views of these experienced men on what geology has done and what it might have done to aid in the conduct of the war. Such a service to be complete must cover all geology, rather than only petroleum geology. At present it must be handled on a confidential basis. For our own branch of the science this would seem to be a duty of the national service committee and plans for handling it are being formulated.

We understand an effort is in progress to secure all possible information concerning application of science and technology to military uses by our enemies. We have been unable to learn that, in this effort, any thought has been given to learning what the Germans and Japanese have done with the science of geology. We feel this should be included in the program and will use our best efforts to that end.

The committee has continued to function as an advisor to geologists and to employers who wished reliable information concerning Selective Service regulations, and procedure by which enlisted men might be released from the armed services. This activity alone would not justify the continuance of the committee. Action has been taken by individual members rather than by the committee as a whole, and these members are so well known in their districts that they could and would continue to render this service if the committee were discontinued.

It is recommended that the committee be continued. The Association should have a functioning unit which will be in position to take action immediately whenever opportunity presents. It should maintain contact with other organizations that are striving to make science more completely serve our military needs. It should accumulate the factual and observational data that will definitely establish the part geology can and should play in war.

K. C. HEALD, *chairman*

EXHIBIT IX. REPORT OF GEOLOGIC NAMES AND CORRELATIONS COMMITTEE

The geologic names and correlations committee can report progress, principally by its Carboniferous and post-Cretaceous subcommittees. The Mesozoic subcommittee, which is the newest, has marked time during the past year because its members did not have time for committee work. Correlation problems can best be discussed and solved when the interested geologists and paleontologists can meet together, and this has not been possible for the last two years.

M. G. Cheney, chairman of the Carboniferous subcommittee, published the final report of his committee in the February *Bulletin*, and it is an excellent report. It was published in two sections. The first part represents the opinion of all the members of the committee, and the second part represents Mr. Cheney's personal opinions on some matters that were not fully agreed to by the full committee. This arrangement was to compromise a difference of opinion that otherwise would have delayed the publication of the report. Mr. Cheney and the other committee members deserve much praise for the time and effort they put into their review of the Mississippian and Pennsylvanian nomenclature.

The post-Cretaceous subcommittee, under W. Armstrong Price, is making definite progress, particularly in Louisiana and Mississippi. The geologists in different parts of Louisiana are actively arguing their use of different geologic names and formation boundaries, and as soon as they can meet and become familiar with each other's ideas we should be able to report definite progress. In Mississippi and western Alabama they are actively working on their correlation charts and have suggested some interesting changes that are under consideration by the subcommittee. In the southeastern states, which include Florida, Georgia, and eastern Alabama, the local geologists are collecting new information on their stratigraphy as wells are drilled and progress has been made, but much work remains to be done before any definite conclusions can be drawn. The necessary work in Texas is relatively complete and needs only to be fitted into the correlations of formations farther east.

The Mesozoic subcommittee, under Ralph W. Imlay, has been relatively inactive because the chairman and other members have been too busy under war conditions to devote much time to committee work. Dr. Imlay has asked to be relieved of this responsibility, and apparently it will be necessary to reorganize this subcommittee since its work is important and should be carried ahead in the future. A study group in East Texas has been organized by the local society to study the stratigraphy of the Upper and Lower Cretaceous. A committee member of California reports that there are many questions to be solved regarding stratigraphic nomenclature near the Cretaceous-Tertiary boundary.

At the 1944 meeting of the geologic names and correlations committee its chairman was instructed to appoint another subcommittee for a long-range study of the Paleozoic. He has not appointed this committee because under war conditions a suitable man could not be selected as chairman. As soon as possible this Paleozoic subcommittee should be organized to start its work. The geologic names and correlations committee seems to be moving toward a set-up of three probably permanent subcommittees to continuously study and review the Paleozoic, Mesozoic, and Tertiary problems of stratigraphy and nomenclature. This is constructive useful work and should be continued.

JOHN G. BARTRAM, *chairman*

EXHIBIT X. REPORT OF COMMITTEE ON APPLICATIONS OF GEOLOGY
(Will be published when available)

EXHIBIT XI. REPORT OF MEDAL AWARD COMMITTEE

During the past year the medal award committee has—

1. Completed the Medal Fund;

2. Nominated the first recipient of the Sidney Powers Memorial medal;
3. Composed rules for the President's Award;
4. Nominated the first recipient of the President's Award.

Medal Fund.—The last annual report of the medal award committee showed a total of 795 contributors who gave \$5,777.25 to the fund. A supplementary report was published in the August, 1944, *Bulletin* which showed 800 contributors had sent in \$5,807.25, and that E. DeGolyer had contributed \$4,192.75 to bring this fund to its goal of \$10,000. After payment for executing the design of the medal, cutting of the dies and investing \$9,300 in Series G War Bonds, there remained a small cash balance. Since the report in August four contributions totaling \$35 have been received for the Medal Fund (principal account) and two contributions totaling \$75 for the Medal Fund (income account). Contributions and accruals to the income account were adequate for the purchase of the medal awarded March 27, 1945.

Medal Award.—The committee, through extensive correspondence, formulated a set of criteria for examination of candidates for the award. Members then submitted names and qualifications of persons to be considered for the award. These candidates and their qualifications were sent to the committee and by a series of preferential mail ballots Wallace E. Pratt was nominated for the award. After approval of the executive committee Pratt was declared the first recipient of the Sidney Powers Memorial medal. The medal and a citation written by E. DeGolyer were presented with appropriate ceremony to Pratt on the evening of March 27, 1945, in Tulsa, Oklahoma.



FIG. 1.—Obverse and reverse views of Sidney Powers Memorial medal.

Figure 1 is a photograph of the medal "in blank." The medal as presented carries the recipient's name stamped (not engraved) on the blank space on the bottom of the reverse side of the medal.

President's Award.—There has for several years been a growing feeling that the Association needed a means to stimulate and reward the younger members of the Association who write papers to be published in the *Bulletin*. Such an award was the subject of discussion at the meeting of the medal award committee on March 21-22, 1944. In due time, through extensive correspondence, the medal award committee formulated and submitted to the executive committee rules for a new award to be called the President's Award. These

rules were approved and the award established by action of the executive committee on October 8, 1944, and were published in the January, 1945, *Bulletin*.

The award consists of \$100 in cash plus a citation, and is given to the author of the article published in the *Bulletin* during the preceding year which made the most significant contribution to petroleum geology. To be eligible an author must not have reached his fortieth birthday on January 1 of the year in which his article appears.

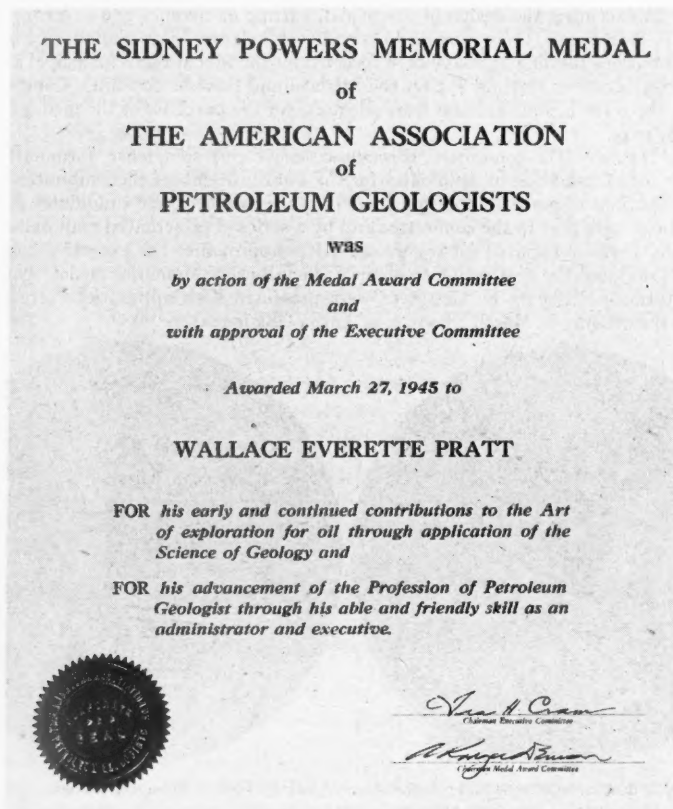


FIG. 2.—Citation presented to Wallace E. Pratt. Size of original: 12×16 inches.

A list of papers which made significant contributions was proposed by the members of the committee and other qualified persons. Through a series of preferential mail ballots the article "Structure of South Louisiana Deep-Seated Domes" (September, 1944, *Bulletin*), was judged by the committee to have made the most significant contribution. After approval by the executive committee the author, W. E. Wallace, Jr., was declared the recipient for 1944. The first award was made with appropriate ceremony on the evening of March 27, 1945, in Tulsa, Oklahoma.

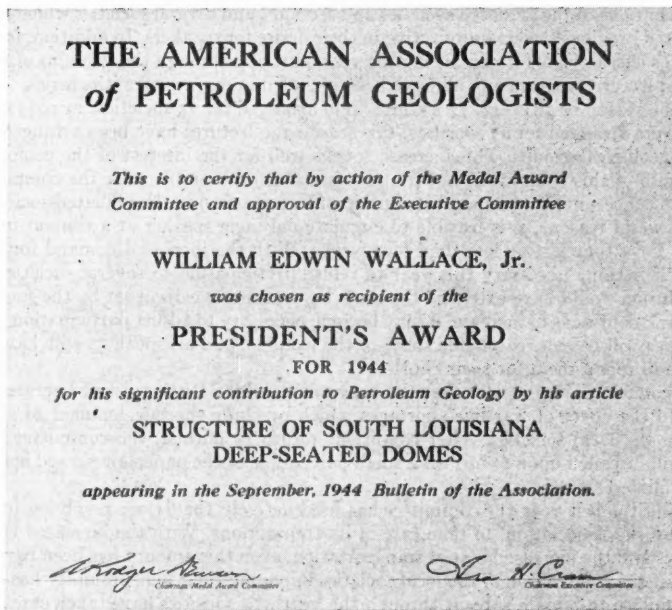


FIG. 3.—Reproduction of citation given W. E. Wallace, Jr.
Size of original: 12X13 inches.

Due to wartime restrictions on travel and the great distances separating our members, the committee could not meet in person during the year. The cancellation of the annual meeting of the Association prevented the regular meeting which would have been held at that time. The chairman desires to take this opportunity to express his thanks and deep appreciation for the fine coöperation in connection with the very extensive correspondence necessary to carry on the business of this committee during the past year.

A. RODGER DENISON, chairman

EXHIBIT XII. REPORT OF DISTINGUISHED LECTURE COMMITTEE

The distinguished lecture committee wishes first to pay its respects to those able and well informed men who during the 1944-45 season agreed to give their time and energy in order to present personally to the geologists of America their contributions to geologic thought. These men are the following.

Charles B. Read	—United States Geological Survey
Watson H. Monroe	—United States Geological Survey
Judson L. Anderson	—The Johns Hopkins University
Kirk Bryan	—Harvard University
Charles E. Weaver	—University of Washington
Philip S. Smith	—United States Geological Survey
William C. Krumbein	—Beach Erosion Board, U. S. War Department
M. King Hubbert	—Shell Oil Company, Inc.
Fred M. Bullard	—University of Texas

This third year of the committee's activities has witnessed continued increase in the interest of the affiliated societies in the committee's program. Speakers have been brought

before all but one of the affiliated societies and sections, and several societies which had not participated previously were quite active in their desire for speakers. In addition, four new geological societies were formed during the year, partially through the stimulus of the distinguished lecture program and all have been included in one or more itineraries.

For the season of 1942-43, 77 lectures were arranged for 25 societies; in 1943-44, 110 lectures were arranged for 27 societies; this season 130 lectures have been arranged for 36 separate geological groups. This increase speaks well for the interest of the geologists in the program of this committee, but it also poses a definite problem for the committee in the future concerning the proper distribution of lectures among the affiliated societies.

For several reasons, it is feasible to circulate only one speaker at a time at monthly intervals for a tour lasting less than four weeks. With the increased demand for certain lectures, it became necessary this year to refuse participation to several societies, since their inclusion would have extended the tours beyond the time limit set by the speaker. If the demand continues to increase, it may become necessary to adjust participation so that all societies will have a reasonable share of the lectures, and all speakers will have tours adequate to repay them for their efforts.

The committee appreciates that the heavy demand for Distinguished Lectures is due in part to the effect of wartime shortages which preclude the development of scientific papers in the local societies. After conditions return to normal, the committee expects that it will be called upon to furnish a small percentage of the papers presented before any of the affiliated societies.

During the last year the committee has used actively the \$1,000 revolving fund, advanced by the Association, to take care of its transactions. With the increased length of itineraries and the increased cost of transportation, even this amount has been barely adequate, but the coöperation of the local societies in paying their bills promptly has enabled the committee to remain solvent through the year. All societies have taken care of their obligations, no unexpected outlays have occurred and the fund is intact. The committee recommends that the fund remain at \$1,000 for the coming year.

During this year the committee achieved the operating goals which it set a year ago since it supplied a complete list of speakers well in advance of the technical season, arranged for a speaker each month during the season and distributed outlines or abstracts of practically all lectures.

Since the committee was first authorized, it has extended its activities somewhat beyond the confines of the Association in order to spread the knowledge of the better life induced by geology. Several colleges and other unaffiliated groups have been included in the itineraries, and more are asking to participate from time to time. It seems to the committee that this interest in a broader knowledge of geology should be stimulated. In fact, it seems apparent that the aims of an "American Geological Institute" as envisioned by Carey Creoneis could best be fostered by a drastic extension of the lecture program to include a three-fold series of lectures, first to the professional geologist, secondly to the geological faculties and students and, thirdly to the general public. The committee recommends consideration by the executive committee of this method for carrying on the Association's part in giving geology a more prominent place in American life.

Finally, the committee feels that the results of these three years of operation amply demonstrate that there is definite need for the Distinguished Lecture Committee as a permanent integral part of the Association's structure, in order that Association members may be kept constantly informed of advances in geology and related sciences. Therefore, the members of the committee recommend that the necessary action be taken to make the distinguished lecture committee a standing committee of the Association.

JOHN L. FERGUSON, *chairman*

WILLIAM J. HILSEWECK

JOHN W. INKSTER

FRED H. MOORE

GROVER E. MURRAY, JR.

EXHIBIT XIII. REPORT OF COMMITTEE FOR PUBLICATION

As in the two years preceding, this committee undertook the task of securing development papers on the various districts. Through the assistance of members present at the Dallas meeting, most of the arrangements for these papers were completed during the session, and the remainder were lined up soon thereafter. By August first all of the papers had been promised.

Experience has shown that this particular phase of Association activity can best be handled by a standing committee, and the committee for publication, with its members selected from all parts of the country has proved extremely coöperative and efficient in this regard. It is strongly recommended that the procedure be continued. The present chairman completes his term of three years at this meeting, but the vice-chairman holds over, and it is recommended that incoming executive arrange that he proceed to make definite plans for the development papers at once, unless a new chairman is to be appointed immediately.

During the past year, the supply of papers for the *Bulletin* having fallen too low for safety, this committee was requested by the editor to take some action to increase the supply. A letter was immediately sent to all committee members requesting that they make an immediate effort to obtain suitable papers, and the response was gratifying, while no large number of papers was obtained, enough were arranged to be of material help, and the results of the effort are still apparent.

At the request of the president and editor, the committee undertook a canvass of a rather large group of members regarding the desirability of publishing a third volume on *Structure of Typical American Oil Fields*. As a result a large amount of information was obtained regarding type of descriptions needed, fields to be described, and the need for re-description of older fields. A summary of this material has been compiled by the chairman and submitted to the executive committee.

Last year a general outline to be followed in compiling and writing development papers was prepared by the committee, with the hope that it would assist in standardizing the material presented, and expedite its preparation. The results seemed satisfactory, and a revised and expanded outline was used this year. It is believed that this practice should be continued.

As no meeting of this committee can be held this year, the chairman wishes to take this opportunity to thank each member for the assistance so generously given. It has made his work a pleasure and a privilege.

J. V. HOWELL, chairman

EXHIBIT XIV. REPORT OF RESEARCH COMMITTEE

The executive committee on August 29, 1944, adopted a resolution directing that the research committee formulate a broad fundamental research program in the field of petroleum geology. According to these instructions, appropriate research projects should be planned and set in motion by any means the research committee may find feasible.

The research committee chairman heartily concurred in the urgency of such a program and promptly appealed to members of the research committee, officers of the affiliated societies, and the Association membership at large for ideas and suggestions regarding what projects are most needed and what ways and means should be employed to accomplish this important task. Under "Research Notes" in the October issue of the *Bulletin*, a preliminary statement, approved by the executive committee, announced this objective and certain proposals regarding its attainment. Obviously, a well balanced plan of research would require a very extensive and long-range program dealing with problems of sedimentation, stratigraphy, structure, and many other subjects bearing on the discovery, devel-

opment, and production of oil. Several proposals have been received and plans are now being formulated for one or more important projects.

The task of outlining a well balanced research program may be performed successfully by an appointive research committee. However, the formulation of definite plans for the many appropriate projects and the continuing study of the progress of such projects would in the writer's opinion, require employment by the Association of a research specialist. Such a coordinator of research activities might also devote attention to personnel and statistical data useful for the efficient operation of the Association and its publications, and assist with technical programs and papers for the *Bulletin* and the special volumes. Also, for the next few years, close attention should be given to problems related to national service.

Efforts of past years have brought publication recently of the *Tectonic Map of North America*. This project was initiated by the National Research Council, Division of Geology and Geography. The research committee of the Association collaborated with chairman Chester A. Longwell, vice-chairman Philip B. King, and others of the National Research Council committee in this large and important undertaking. Publication of this map by the Association arises from the use of funds of the Association to meet costs of engraving, printing, and distribution.

Also, results of research committee conferences and questionnaire on "The Migration and Accumulation of Petroleum and Natural Gas" have been compiled by F. M. Van Tuyl, Ben H. Parker, and W. W. Skeeters and published in the January, 1945, issue of the *Colorado School of Mines Quarterly*. The April, 1944, and April, 1945, issues of this *Quarterly* contain extensive annual reviews of petroleum geology during the preceding year, as a cooperative project by the faculty of the Colorado School of Mines and the Association research committee.

The annual conference and business meeting of the research committee were not held at the time of the March, 1945, meeting of the Association. War conditions also caused near cessation of other projects and activities of the committee.

It is hoped that post-war planning can include many important research projects developed and nurtured by efforts of this committee, aided by active cooperation of research committees of the affiliated societies, by educational and research institutions, and by individual members of the Association.

M. G. CHENEY, chairman

EXHIBIT XV. REPORT OF REPRESENTATIVE ON DIVISION OF
GEOLOGY AND GEOGRAPHY OF NATIONAL RESEARCH
COUNCIL, 1944-1945

Certain research projects in progress over the past decade or more are being completed, even under adverse war conditions.

The recently published *Tectonic Map of the United States*, prepared by the committee on tectonics, is the result of many years of cooperative effort. The work of planning and completing this extensive undertaking is reviewed by the chairman, Chester R. Longwell, in the December, 1944, issue of the *Bulletin*. Members of the United States Geological Survey have carried much of the burden in preparing the map, especially Philip B. King, vice-chairman of the committee. The National Research Council, the Geological Society of America, and the Association have given direct financial support. Final drafting and printing costs were paid from funds of the Association, and distribution of this map is being made from Association headquarters.

Four *Correlation Charts* prepared under direction of the committee on stratigraphy, C. O. Dunbar, chairman, have been published in 1944 in the *Bulletin* of the Geological

Society of America, Vol. 55: Chart No. 1, "Cambrian Formations of North America," by B. F. Howell, chairman, and 9 collaborators; Chart No. 6, "Pennsylvanian Formations of North America," by Raymond C. Moore, chairman, and 25 collaborators; Chart No. 10A, "Cretaceous Formations of Mexico," by Ralph W. Imlay; Chart No. 11, "Marine Cenozoic Formations of Western North America," by Charles E. Weaver, chairman, and 20 collaborators. These charts are accompanied by extensive annotations and selected bibliographies. Five remaining charts in this series of 13 are in various stages of completion.

Glacial Map of North America prepared by the committee under chairmanship of Richard F. Flint has been sent to the Geological Society of America for publication.

The Division has been called upon to aid the Army Map Service in selecting a well distributed but limited number of library depositories for maps of many parts of the earth. These maps are being released as rapidly as requirements of military secrecy permit.

Reports from committee chairmen and representatives of nine constituent societies were presented at the annual meeting of the Division, April 29, 1944. Items of most interest to petroleum geologists include the proposal that a new edition of the symposium, *Recent Marine Sediments*, be prepared soon after the war under direction of the committee on sedimentation, Parker D. Trask, chairman. The committee on measurement of geologic time is giving attention to radioactivity of oil-field waters and radioactivity logging. Alfred C. Lane is chairman. Progress and new publications in micropaleontology were reported by Joseph A. Cushman. Other committee chairmen reviewed plans and recent developments in research work in tectonics, experimental deformation of rocks, paleobotany, marine ecology as related to paleontology, geological personnel, advice to prospective geology students, Latin American studies, geographical research, and many other subjects.

The 1945 annual meeting of the Division has been cancelled. However, reports from committees and constituent societies are to be received as usual on or about May 1.

Attention is called to post-doctorate fellowships available in geology, paleontology, and physical geography and other sciences allotted annually by the National Research Council. Latest announcement regarding these fellowships was published in the December 8, 1944, issue of *Science*.

M. G. CHENEY, *representative*

MINUTES OF BUSINESS COMMITTEE MAYO HOTEL, TULSA, OKLAHOMA

MARCH 27, 1945

The annual business committee meeting was called to order in the Mayo Hotel, Tulsa, Oklahoma, March 27, 1945, 10:15 A.M. by George S. Buchanan, chairman.

1. Roll call by secretary R. E. Rettger showed the following members and alternates present.

Chairman: George S. Buchanan

Vice-chairman: Sheridan A. Thompson

Secretary: Robert E. Rettger

Executive Committee: Ira H. Cram, Robert E. Rettger, A. Rodger Denison, Warren B. Weeks, Gayle Scott

Members-at-large: C. W. Tomlinson, Monroe G. Cheney, Wallace E. Pratt, K. C. Heald, E. DeGolyer (absent)

Representatives

Alternates

Division of Paleontology:

Gayle Scott
Charles Ryniker

District Representatives:

<i>Amarillo:</i>	Elisha A. Paschal	
<i>Appalachian:</i>	M. Gordon Gulley	
<i>Capital:</i>	Carle H. Dane	
<i>Canada:</i>	J. G. Spratt (absent)	
<i>Corpus Christi:</i>		Thornton Davis
<i>Dallas:</i>	Barney Fisher	
<i>East Oklahoma:</i>	R. Clare Coffin	
	D. E. Lounsbery	
	Lucian H. Walker	
<i>Fort Worth:</i>		Lynn K. Lee
<i>Great Lakes:</i>	Stanley G. Elder	
	Darsie A. Green	
<i>Houston:</i>	George S. Buchanan	R. C. Bowles
	Donald M. Davis	W. B. Milton
<i>Michigan:</i>	Rex P. Grant (absent)	
<i>New Mexico:</i>		J. B. Leiser
<i>New York:</i>		Gail F. Moulton
<i>Pacific Coast:</i>		Fritz L. Aurin
		Glenn S. Dille
		A. I. Gregersen
		E. O. Markham
		Stanley G. Wissler
<i>Rocky Mountain:</i>	Charles S. Lavington	
<i>Shreveport:</i>	J. D. Aimer	
<i>South America:</i>	Philip E. Nolan (absent)	
<i>Southeast Coast:</i>	Tom McGlothlin (absent)	
<i>South Louisiana:</i>	Gordon I. Atwater	
<i>South Permian Basin:</i>	John M. Hills	
	F. H. McGuigan	
<i>South Texas:</i>		Thornton Davis
<i>Tyler:</i>	T. C. Cash	
<i>West Oklahoma:</i>	Richard W. Camp	
<i>Wichita:</i>	William C. Imbt	
<i>Wichita Falls:</i>		W. C. Bean

1. *Seating of representatives.*—It was moved, seconded, and carried that members of the business committee not present at roll call be recorded by the secretary if they report to him at the close of the session.

2. *Minutes of previous meeting.*—It was moved, seconded, and carried that the reading of the minutes of the last meeting of the committee be dispensed with, as they have been published in the *Bulletin*.

3. *Report of committee on code of ethics, C. W. Tomlinson, chairman (Exhibit VI).*—It was moved, seconded, and carried unanimously, on the recommendation of the executive committee, that the report on code of ethics be accepted, spread upon the minutes of the meeting, and that consideration of the report be postponed until the 1946 annual meeting of the business committee. (The report of the committee on code of ethics is published in the January *Bulletin*.)

4. *American Geological Institute.*—It was moved, seconded, and carried unanimously,

on the recommendation of the executive committee, that the principles of cooperation as expressed in the constitution of the proposed American Geological Institute be approved; that no action on ratification of the constitution be taken; but that the executive committee study the problem further, and take such action as it deems advisable. (The constitution of the proposed A.G.I. is published in the February *Bulletin*.)

5. *Report of committee on method of election of officers, John G. Bartram, chairman (Exhibit VII).*—(1) It was moved, seconded, and carried (standing vote of 34 yes and 8 no), on the recommendation of the executive committee, that the report of the committee on method of election of officers be accepted, spread upon the minutes of this meeting, and that consideration of the report be postponed until the 1946 annual meeting of the business committee.

(2) It was moved, seconded, and carried, on recommendation of the executive committee, that the attached questionnaire or one designed to accomplish the same purpose be sent to the membership before May 1, 1945; that a committee of 7 be appointed by the president to study all replies received by July 1, 1945; that the committee recommend a system of election based upon the replies; that the committee send its report to the executive committee by November 15, 1945; that the report be published in the January, 1946, *Bulletin*; and that the report be considered at the annual meeting of the business committee in 1946.

QUESTIONNAIRE

Your replies to the following questions will guide the committee on method of election of officers in devising a new method of election, in the event a change in the present system is deemed desirable by the majority of members. Please study the questionnaire carefully. Not all possible systems of nomination and voting are included, but the more important ones are believed to be. The privilege of writing in other nominations is included in all suggested systems of mail balloting.

If you vote yes on Question 1, ignore the rest of the questionnaire.

1. Do you favor the present system of election of officers?

If you vote yes to Question 2, choose one system suggested by Questions 3-12 by voting yes in the column of your choice, or recommend an alternate system under Question 15.

	Voting at Annual Meeting	Mailed Ballot After Meeting at Which Nominations Made	Mailed Ballot and Nominations Between Meetings
2. Do you favor a change in the present system of election of officers?			
3. Nominations from floor.....	XXXXXX		XXXXXXXX
4. Nominating committee appointed by president—2 or more slates.....		XXXX	
5. Nominating committee appointed by president—1 slate, others from floor.....			XXXXXXXX
6. Nominating committee appointed by president—1 slate, others by petition.....			
7. Nominating committee appointed by president—1 slate, others—floor and/or petition.....			XXXXXXXX
8. Nominating committee appointed by business committee—2 or more slates.....		XXXX	
9. Nominating committee appointed by business committee—1 slate, others from floor.....			XXXXXXXX
10. Nominating committee appointed by business committee—1 slate, others by petition.....			
11. Nominating committee appointed by business committee—1 slate, others—floor and/or petition.....			XXXXXXXX
12. Nomination by petition only.....			
a. How many must sign the petition?			
13. If you vote yes on any of Questions 4 to 11, should the nominating committee be composed of:			
a. Past officers			
b. Past officers and members			
c. Members only			
14. If you vote yes on any of Questions 6, 7, 10 or 11, how many must sign the petition?			
15. Remarks.			

6. *Committee on statistics of exploratory drilling.*—It was moved, seconded, and carried, on the recommendation of the executive committee, that the business committee approve and recommend to the annual business meeting of the Association the following amendments to the by-laws.

Change the by-laws, Article VI, Section 1, first paragraph, to read as follows.

"There shall be the following standing committees: business committee; research committee; committee on geologic names and correlations; committee on applications of geology; committee for publication; finance committee; committee on statistics of exploratory drilling; trustees of revolving publication fund; trustees of research fund; and medal award committee."

Add new Section 12 under Article VI of by-laws as follows.

Committee on Statistics of Exploratory Drilling

"SECTION 12. The function of the committee on statistics of exploratory drilling shall be to assemble and compile statistics on the methods used to locate exploratory wells and on the results of exploratory drilling for oil and gas, and annually to submit for publication in the *Bulletin* a report summarizing and analyzing these data. This committee shall consist of twenty-four members unless a different number is authorized by the executive committee."

Recess for lunch at 12:05 P.M.

Recessed meeting was called to order by chairman Buchanan at 1:35 P.M.

7. *Report of national service committee, K. C. Heald, chairman (Exhibit VIII).*—It was moved, seconded, and carried that the report with its recommendation be accepted and referred to the annual business meeting, with the recommendation that it be not read, but that it be published in the *Bulletin*.

8. *Report of geologic names and correlations committee, John G. Bartram, chairman (Exhibit IX).*—It was moved, seconded, and carried that the report be accepted and referred to the annual business meeting, with the recommendation that it be not read, but that it be published in the *Bulletin*.

9. *Report of committee on applications of geology, Paul Weaver, chairman (Exhibit X).*—It was moved, seconded, and carried that the report be published in the *Bulletin*. (The chairman of the committee was absent; no report was presented.)

10. *Report of medal award committee, A. Rodger Denison, chairman (Exhibit XI).*—It was moved, seconded, and carried that the report be accepted and referred to the annual business meeting, with the recommendation that it be not read, but that it be published in the *Bulletin*.

11. *Report of distinguished lecture committee, John L. Ferguson, chairman (Exhibit XII).*—It was moved, seconded, and carried that the report be accepted and referred to the annual business meeting, with the recommendation that it be not read, but that it be published in the *Bulletin*.

12. *Report of committee for publication, J. V. Howell, chairman (Exhibit XIII).*—It was moved, seconded, and carried that the report be accepted and referred to the annual business meeting, with the recommendation that it be not read, but that it be published in the *Bulletin*.

13. *Report of research committee, M. G. Cheney, chairman (Exhibit XIV).*—It was moved, seconded, and carried that the report be accepted and referred to the annual business meeting, with the recommendation that it be not read, but that it be published in the *Bulletin*.

14. *Report of representative on National Research Council Division of Geology and Geography, M. G. Cheney (Exhibit XV).*—It was moved, seconded, and carried that the report be accepted and referred to the annual business meeting, with the recommendation that it be not read, but that it be published in the *Bulletin*.

A rising vote of thanks was given the chairmen and members of the standing and special committees.

The annual meeting of the business committee adjourned at 2:45 P.M.

GEORGE S. BUCHANAN, *chairman*

ROBERT E. RETTGER, *secretary*

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

CONSTITUTION¹

ARTICLE I. NAME

This Association shall be called "The American Association of Petroleum Geologists," incorporated under the laws of Colorado.

ARTICLE II. OBJECT

The object of this Association is to promote the science of geology, especially as it relates to petroleum and natural gas; to promote the technology of petroleum and natural gas and to encourage improvements in the methods of exploring for and exploiting these substances; to foster the spirit of scientific research amongst its members; to disseminate facts relating to the geology and technology of petroleum and natural gas.

ARTICLE III. MEMBERSHIP

Members

SECTION 1. Any person engaged in the work of petroleum geology or in research pertaining to petroleum geology or technology is eligible to active membership, provided he is a graduate of an institution of collegiate standing, in which institution he has done his major work in geology, or in sciences fundamental to petroleum geology, and in addition has had the equivalent of three years' experience in petroleum geology or in the application of these other sciences to petroleum geology or to research in petroleum geology or technology; and provided further that in the case of an applicant for membership who has not had the required collegiate or university training, but whose standing in the profession is well recognized, he shall be admitted to membership when his application shall have been favorably and unanimously acted upon by the executive committee; and provided further that these requirements shall not be construed to exclude teachers and research workers in recognized institutions, whose work is of such character as in the opinion of the executive committee shall qualify them for membership.

Active members alone shall be known as members.

Life Members

SECTION 2. The executive committee may grant life membership to members who have paid their dues and are otherwise qualified.

Associates

SECTION 3. Any person having completed as much as thirty hours of geology (an hour shall here be interpreted as meaning as much as sixteen recitation or lecture periods of one hour each, or the equivalent in laboratory) in a reputable institution of collegiate or university standing, or who has done field work equivalent to this, is eligible to associate membership, provided at the time of his application for membership he shall be engaged in geological studies in an institution of collegiate or university standing, or shall be engaged in petroleum geology; and any person who is a graduate of an institution of collegiate standing in which he has done his major work in sciences fundamental to petroleum geology or petroleum technology, and who has the equivalent of one year's experience in the application of

¹ The constitution and by-laws were adopted 1918, and amended 1921, 1922, 1923, 1925, 1927, 1928, 1929, 1930, 1932, 1933, 1935, 1936, 1939, 1940, 1942, 1943, 1944, and 1945.

his science to the study of petroleum geology, shall be eligible to associate membership, provided at the time of his application for membership he shall be engaged in investigations in the broader subject of petroleum geology and technology.

Associate members shall be known as associates.

Associates shall enjoy all the privileges of membership in the Association, save that they shall not hold office, sign applications for membership, or vote; neither shall they have the privilege of advertising their affiliation with the Association in professional cards or professional reports or otherwise.

The executive committee may advance to active membership, without the formality of application for such change, those associates who have, subsequent to election, fulfilled the requirements for active membership.

Election to Membership

SECTION 4. Every candidate for admission as a member or associate shall submit a formal application on an application form authorized by the executive committee, signed by him, and endorsed by not less than three members who are in good standing, stating his training and experience and such other facts as the executive committee shall from time to time prescribe. Provided the executive committee, after due consideration, shall judge that the applicant's qualifications meet the requirements of the constitution, they shall cause to be published in the *Bulletin* the applicant's name and the names of his sponsors. If, after at least thirty days have elapsed since such publication, no reason is presented why the applicant should be not admitted, he shall be deemed eligible to membership or to associate membership, as the case may be, and shall be notified of his election.

SECTION 5. An applicant for membership, on being notified of his election in writing, shall pay full membership dues for the current year and on making such payment shall be entitled to receive the entire *Bulletin* for that year. Unless payment of dues is made within thirty (30) days by those living within the continental United States and within ninety (90) days by those living elsewhere, after notice of election has been mailed, the executive committee may rescind the election of the applicant. Upon payment of dues, each applicant for membership shall be furnished with a membership card for the current year, and until such written notice and card are received, he shall in no way be considered a member of the Association.

Honorary Members

SECTION 6. The executive committee may from time to time elect as honorary members persons who have contributed distinguished service to the cause of petroleum geology. Honorary members shall not be required to pay dues.

ARTICLE IV. OFFICERS AND THEIR DUTIES

Officers

SECTION 1. The officers of the Association shall be a president, a vice-president, a secretary-treasurer, and an editor. These, together with the past-president, shall constitute the executive committee and managers of the Association.

SECTION 2. The officers shall be elected annually from the Association at large by written ballot deposited in a locked ballot box by those members, present at the annual meeting, who have paid their current dues and are otherwise qualified under the constitution. Each candidate, when voted for as a candidate for the particular office for which he is nominated, shall be thereby automatically voted for as a candidate for the executive committee for one year, except that candidates for the presidency shall be automatically voted for as candidate for the executive committee for two years.

SECTION 3. No one shall hold the office of president for two consecutive years and no

one shall hold any other office for more than two consecutive years except the editor who shall not hold office for more than six consecutive years.

Duties of Officers

SECTION 4. The president shall be the presiding officer at all meetings of the Association, shall take cognizance of the acts of the Association and of its officers, shall appoint such committees as are required for the purposes of the Association, and shall delegate members to represent the Association. He may, at his option, serve on, and may be chairman of, any committee.

SECTION 5. The vice-president shall assume the office of president in case of a vacancy from any cause in that office and shall assume the duties of president in case of the absence or disability of the latter. If the past-president shall for any reason be unable to serve as a member of the executive committee, the president shall fill the vacancy by the appointment of the next available preceding past-president.

A vacancy or disability occurring in the office of vice-president, secretary-treasurer, or editor shall be filled by majority vote of the executive committee, either for the unexpired term or for the period of disability, as the committee may decide. In the case of a tie, the president shall cast the deciding vote.

SECTION 6. The secretary-treasurer shall assume the duties of president in case of the absence of both the president and vice-president. He shall have charge of the financial affairs of the Association and shall annually submit reports as secretary-treasurer covering the fiscal year. He shall receive all funds of the Association, and, under the direction of the executive committee, shall disburse all funds of the Association. He shall cause an audit to be prepared annually by a public accountant at the expense of the Association. He shall give a bond, and shall cause to be bonded all employees to whom authority may be delegated to handle Association funds. The amount of such bonds shall be set by the executive committee and the expense shall be borne by the Association. The funds of the Association shall be disbursed by check as authorized by the executive committee.

SECTION 7. The editor shall be in charge of editorial business, shall submit an annual report of such business, shall have authority to solicit papers and material for the *Bulletin* and for special publications, and, with the approval of the executive committee, may accept or reject material offered for publication. He may appoint associate, regional, and special editors.

SECTION 8. The officers shall assume the duties of their respective offices immediately after the annual meeting in which they are elected.

ARTICLE V. EXECUTIVE COMMITTEE—MEETINGS AND DUTIES

Executive Committee

SECTION 1. The executive committee shall consist of the president, past-president, vice-president, secretary-treasurer, and editor.

Meetings and Duties

SECTION 2. The executive committee shall meet immediately preceding the annual meeting and at the call of the president may hold meetings when and where thought advisable, to conduct the affairs of the Association. A joint meeting of the outgoing and incoming executive committees shall be held immediately after the close of the annual Association business meeting. Members of the executive committee may vote by proxy on matters which require a unanimous vote.

SECTION 3. The executive committee shall consider all nominations for membership and pass on the qualifications of the applicants; shall have control and management of the affairs and funds of the Association; shall determine the manner of publication and

pass on the material presented for publication; and shall designate the place of the annual meeting. They are empowered to establish a business headquarters for the Association, and to employ such persons as are needed to conduct the business of the Association. They are empowered to accept, create, and maintain special funds for publication, research, and other purposes. They are empowered to make investments of both general and special funds of the Association. Trust funds may be created, giving to the trustees appointed for such purpose, such direction as to investments as seems desirable to the executive committee to accomplish any of its objects and purposes, but no such trust funds shall be created unless they are revocable upon ninety (90) days' notice.

ARTICLE VI. MEETINGS

The Association shall hold at least one stated meeting each year, which shall be the annual meeting. This meeting shall be held in March or April at a time and place designated by the executive committee. At this meeting the election of members shall be announced, the proceedings of the preceding meeting shall be read, Association business shall be transacted, scientific papers shall be read and discussed and officers for the ensuing year shall be elected.

ARTICLE VII. AMENDMENTS

Amendments to this constitution may be proposed by a resolution of the executive committee, by a constitutional committee appointed by the president, or in writing by any ten members of the Association. All such resolutions or proposals must be submitted at the annual meeting of the business committee of the Association as provided in the by-laws, and only the business committee shall make recommendations concerning proposed constitutional changes at the annual Association business meeting. If such recommendations by the business committee shall be favorably acted on at the annual Association business meeting, the secretary-treasurer shall arrange for a ballot of the membership by mail within thirty (30) days after said annual Association business meeting, and a majority vote of the ballots received within ninety (90) days of their mailing shall be sufficient to amend. The legality of all amendments must be determined by the executive committee prior to balloting.

BY-LAWS

ARTICLE I. DUES

SECTION 1. The fiscal year of the Association shall correspond with the calendar year.

SECTION 2. The annual dues of members of the Association shall be ten dollars (\$10.00). The annual dues of associates for not to exceed three years after election shall be six dollars (\$6.00); for the second three-year period eight dollars (\$8.00); thereafter, the annual dues of such associates shall be ten dollars (\$10.00). The annual dues are payable in advance on the first day of each calendar year. A bill shall be mailed to each member and associate before December first of each year, stating the amount of the annual dues and the penalty and conditions for default in payment. Members or associates who shall fail to pay their annual dues by January first shall not receive copies of the January *Bulletin* or succeeding *Bulletins*, nor shall they be privileged to buy Association special publications at prices made to the membership, until such arrears are met.

During any period in which the United States is actually engaged in war and for a period of one year thereafter, the executive committee may at its discretion suspend, reduce, or waive annual dues to members or associate members serving in the armed forces of the United States or any allied country, without otherwise affecting their membership, except that they shall not receive the *Bulletin* during a period for which no dues are paid.

SECTION 3. On the payment of two hundred dollars (\$200.00) any member in good standing shall be declared a life member and thereafter shall not be required to pay an-

nual dues. The funds derived from this source shall be placed in a permanent investment, the income from which shall be devoted to the same purposes as the regular dues.

ARTICLE II. RESIGNATION—SUSPENSION—EXPULSION

SECTION 1. Any member or associate may resign from the Association at any time. Such resignation shall be in writing and shall be accepted by the executive committee, subject to the payment of all outstanding dues and obligations of the resigning member or associate.

SECTION 2. Any member or associate who is more than a year delinquent (in arrears) in payment of dues shall be suspended from the Association. Any delinquent or suspended member or associate, at his own option, may request in writing that he be dropped from the Association and such request shall be granted by the executive committee. Any member or associate more than two years in arrears shall be dropped from the Association. The time of payment of delinquent dues for either one year or two years may be extended by unanimous vote of the executive committee.

SECTION 3. Any member or associate who resigns or is dropped under the provisions of Sections 1 and 2 of this article ceases to have any rights in the Association and ceases to incur further indebtedness to the Association.

SECTION 4. Any person who has ceased to be a member or associate under Section 1 or Section 2 of this article may be reinstated by unanimous vote of the executive committee subject to the payment of any outstanding dues and obligations which were incurred, prior to the date when he ceased to be a member or associate of the Association.

In the case of any member or associate who has been dropped between the dates of January 1, 1931, and January 1, 1936, for non-payment of dues and who shall apply for reinstatement, the executive committee is authorized, at its discretion, to accept the resignation of such member or associate effective at any date during such period of delinquency, provided, the member shall pay all indebtedness to the Association incurred prior to the date of such resignation including a proper proportion of annual dues as shall be fixed by the executive committee. Such member or associate shall not be entitled to receive the *Bulletin* for any period subsequent to the date when his resignation became effective and prior to his reinstatement.

SECTION 5. Any member or associate who, after being granted a hearing by the executive committee, shall be found guilty of a violation of the code of ethics of this Association, or shall be found guilty of a violation of the established principles of professional ethics, or shall be found guilty of having made a false or misleading statement in his application for membership in the Association, may be suspended or expelled from the Association by unanimous vote of the executive committee. The decision of the executive committee in all matters pertaining to the interpretation and execution of the provisions of this section shall be final.

ARTICLE III. PUBLICATIONS

SECTION 1. The proceedings of the annual meeting and the papers presented at such meetings shall be published at the discretion of the executive committee in the Association *Bulletin* or in such other form as the executive committee may decide best meets the needs of the membership of the Association.

SECTION 2. The payment of annual dues for any fiscal year entitles the member or associate to receive without further charge a copy of the *Bulletin* of the Association for that year.

SECTION 3. The executive committee may authorize the printing of special publications to be financed by the Association from its general, publication, or special funds and offered for sale to members and associates in good standing at not less than cost of publication and distribution.

ARTICLE IV. REGIONAL SECTIONS, TECHNICAL DIVISIONS,
AND AFFILIATED SOCIETIES

SECTION 1. Regional sections of the Association may be established provided the members of such sections are members of the Association and shall perfect an organization and make application to the executive committee. The executive committee shall submit the application to a vote at a regular annual meeting, an affirmative vote of two-thirds of the members present and voting being necessary for the establishment of such a section; and provided that the Association may revoke the charter of any regional section by a vote of two-thirds of the members present and voting at a regular annual meeting.

SECTION 2. Technical divisions may be established, provided the members interested shall perfect an organization and make application to the executive committee. The executive committee shall submit the application to a vote at a regular meeting, an affirmative vote of two-thirds of the membership present and voting being necessary for the establishment of such a division. In like manner, the Association may dissolve a division by an affirmative vote of two-thirds of the members present and voting at any annual meeting. A technical division may have its own officers, and it may have its own constitution and by-laws provided that, in the opinion of the executive committee, these do not conflict with the constitution and by-laws of the Association. The executive committee shall be empowered to make arrangements with the officers of the division for the conduct of the business of the division. A division may admit to affiliate membership in the division specially qualified persons who are not eligible to membership in the Association. Technical divisions may affiliate with other scientific societies, with the approval of the executive committee.

SECTION 3. Subject to the affirmative vote of two-thirds of the membership present and voting at an annual meeting, and with legal advice, the executive committee may arrange for the affiliation with the Association of duly organized groups or societies, which by objects, aims, constitutions, by-laws, or practice are developing the study of geology or petroleum technology. In like manner and with like advice, the executive committee may arrange conditions for dissolution of such affiliations. Affiliation with the Association need not prevent affiliation with other scientific societies. Members of affiliated societies who are not members of the Association, shall not have the privilege of advertising their affiliation with the Association on professional cards or otherwise.

ARTICLE V. DISTRICT REPRESENTATIVES

The executive committee shall cause to be elected district representatives from districts which it shall define by a local geographic grouping of the membership. Such districts shall be redesignated and redefined by the executive committee as often as seems advisable. Each district shall be entitled to one representative for each seventy-five members, but this shall not deprive any designated district of at least one representative. The representatives so apportioned shall be chosen from the membership of the district by a written ballot arranged by the executive committee. They shall hold office for two years, their term of office expiring at the close of the annual meeting.

ARTICLE VI. COMMITTEES

Appointment and Tenure

SECTION 1. There shall be the following standing committees: business committee; research committee; committee on geologic names and correlations; committee on applications of geology; committee for publication; finance committee; committee on statistics of exploratory drilling; trustees of revolving publication fund; trustees of research fund; and medal award committee.

The president shall appoint all standing committees except the business committee and the medal award committee, for which provision is hereafter made. Members of all

committees except the business committee shall serve for a three-year term, but in rotation, with one-third of the members being appointed each year. The president shall designate the chairmen, annually, shall have power to fill vacancies, and shall notify the members of the committees of their appointment. The president may designate one or more vice-chairmen annually.

In addition to the aforesaid standing committees, the president shall appoint annually or semiannually a resolutions committee, and such special committees as the executive committee may authorize. Special committees shall be appointed for a term of one year. The president shall designate the chairmen of such committees.

Business Committee

SECTION 2. The business committee shall act as a council and advisory board to the executive committee and the Association. This committee shall consist of the executive committee, not more than five members at large appointed annually by the president, two members elected by and from each technical division, and the district representatives. The president shall also appoint annually a chairman and a vice-chairman, but neither of these need be one of those otherwise constituting the business committee. The secretary-treasurer shall act as secretary of the business committee. If a district or technical representative is unable to be present at any meeting of the committee he may designate an alternate, who, in the case of a district representative, may or may not be a resident of the district he is asked to represent, and the alternate, on presentation of such a designation in writing, shall have the same powers and privileges as a regularly chosen representative. The business committee shall meet the day before the annual meeting at which all proposed changes in the constitution or by-laws shall be considered, all old and new business shall be discussed, and recommendations shall be voted for presentation at the annual meeting.

Research Committee

SECTION 3. The purpose of the research committee is the advancement of research, particularly within the field of petroleum geology. The committee shall consist of twenty-four members unless a different number is authorized by the executive committee.

Committee on Geologic Names and Correlations

SECTION 4. The purpose of the committee on geologic names and correlations is to lend assistance to authors on problems on stratigraphy and nomenclature and to advise the editor and executive committee in regard to the propriety of the use of stratigraphic names and correlations in papers submitted for publication by the Association. The committee shall consist of fifteen members unless a different number is authorized by the executive committee.

Committee on Applications of Geology

SECTION 5. The object of the committee on applications of geology is to advise and promote ways and means for informing the general public on all phases of geology particularly on the natural occurrence of oil and gas underground, the methods of searching for these substances, and the methods of exploiting them. The committee shall consist of twelve members unless a different number is authorized by the executive committee.

Committee for Publication

SECTION 6. The purpose of the committee for publication is to assist in securing desirable manuscripts for publication in the *Bulletin* or other publications of the Association. The committee may also assist in securing papers for delivery at the annual meetings. The committee shall consist of twenty-four members unless a different number is authorized by the executive committee.

Finance Committee

SECTION 7. The finance committee shall act as financial advisers to the executive committee. The committee shall consist of three members. If a member of the finance committee should be elected to the executive committee he shall resign from the finance committee and the president shall appoint a member of the Association to complete his unexpired term.

Trustees of Revolving Publication Fund

SECTION 8. Before any publication project shall be undertaken with the use of the revolving publication fund the approval of the trustees and the executive committee must be secured. There shall be three trustees. If a trustee should be elected to the executive committee he shall resign as a trustee and the president shall appoint a member of the Association to complete his unexpired term.

Trustees of Research Fund

SECTION 9. Before any research work may be undertaken with the use of money from the research fund, the approval of the trustees and the executive committee shall be secured. There shall be three trustees. If a trustee shall be elected to the executive committee he shall resign as a trustee and the president shall appoint a member of the Association to complete his unexpired term.

Resolutions Committee

SECTION 10. The resolutions committee shall be charged with the duty of presenting at the annual and semi-annual meetings resolutions expressing the Association's appreciation and thanks to those who have worked and contributed to the success of the meetings.

Medal Award Committee

SECTION 11. The purpose of the committee shall be to choose recipients for all medals or other awards which may be established by the executive committee. The committee shall consist of nine members and three ex-officio members. The nine members of the original committee shall be appointed by the president, three of whom shall serve for three years, three for two years, and three for one year. One of each of the groups appointed for the different lengths of time shall be a former president of the Association. Each incoming president shall thereafter appoint three members of the committee to serve for three years, one of which shall be a former president of the Association. Vacancies on the committee due to resignation or other causes shall be immediately filled by the president. The ex-officio members shall be: (1) the president of the Association, (2) the president of the Society of Exploration Geophysicists, (3) the president of the Society of Economic Paleontologists and Mineralogists. The president of the Association shall be the chairman of the committee, unless he shall, at his election, name a chairman to serve for one year.

Committee on Statistics of Exploratory Drilling

SECTION 12. The function of the committee on statistics of exploratory drilling shall be to assemble and compile statistics on the methods used to locate exploratory wells and on the results of exploratory drilling for oil and gas, and annually to submit for publication in the *Bulletin* a report summarizing and analyzing these data. This committee shall consist of twenty-four members unless a different number is authorized by the executive committee.

ARTICLE VII. AMENDMENTS

These by-laws may be amended by vote of three-fourths of the members present and voting at any annual meeting, provided that such changes shall have been recommended to the meeting by the business committee and provided that their legality shall be determined by the executive committee prior to publication.

AT HOME AND ABROAD

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

Newly elected officers of the Society of Exploration Geophysicists, announced at the annual meeting, at Tulsa, Oklahoma, April 4, are: president, HENRY C. CORTES, Magnolia Petroleum Company, Dallas, Texas; vice-president, J. J. JAKOSKY, University of Southern California, Los Angeles; editor, L. L. NETTLETON, Gulf Research Laboratory, Pittsburgh, Pennsylvania; secretary-treasurer, CECIL H. GREEN, Geophysical Service, Inc., Dallas, Texas.

The Shreveport Geological Society, Shreveport, Louisiana, plans to have its forthcoming publication, *The Important Oil and Gas Fields of North Louisiana, South Arkansas, Mississippi, and Alabama*, ready for distribution in August. The book will present the salient features of fifty-five fields. The pre-publication price is \$10; regular price, \$12.50 per copy. L. H. MELTZER, Box 1407, Shreveport, is secretary-treasurer of the society.

The South Texas Geological Society listened to FRED B. PLUMMER, of the University of Texas Bureau of Economic Geology, Austin, talk on "The Future of Oil Supplies after Depletion of Our Present Reserves," at San Antonio, Texas, March 29. The same paper was presented before the Houston Geological Society on April 5.

ADRIAN H. HEATON, of the Sinclair Prairie Oil Company, Corpus Christi, Texas, died last month at the age of 46 years.

W. R. JOHNSON, formerly with the Sun Oil Company, at Midland, Texas, has joined The Texas Company at Ardmore, Oklahoma.

Major A. CLIVE MENDELSON, R.A.F.C., of 4 Cavendish Place, Brighton, Sussex, England, has returned from service overseas.

JAMES G. WHITE has left the Humble Oil and Refining Company. He is with the Standard Oil Company of Egypt, 22 Sharia Kassel Nil, Cairo, Egypt.

JOE H. E. WARD, formerly with the Forest Development Corporation, is employed by the Mid-Continent Petroleum Corporation, San Antonio, Texas.

Captain HILLORD HINSON is in the Adjutant Generals School at Fort Sam Houston, Texas. His home address is 3607 MacArthur Drive, Fort Smith, Arkansas.

GORDON W. PRESCOTT, of the Halliburton Oil Well Cementing Company, is with the 5th Headquarters Special Troop, Camp Swift, Texas.

FRANCIS P. SHEPARD is at the Scripps Institution of Oceanography, La Jolla, California.

T. F. GRIMSDALE may be addressed in care of Lloyds Bank, Ltd., 263 Tottenham Court Road, London, England.

The Pacific Section of the A.A.P.G. heard JAMES GILLULY, March 23, at the University Club in Los Angeles, California, discuss engineering problems confronting the United States military command during operations in the Southwest Pacific. Gilluly has resumed his duties at the University of California at Los Angeles after spending 8 months in the Pacific region.

NOYES B. LIVINGSTON is chief geologist for Yacimientos Petroliferos Fiscales Bolivianos, Sanandita, Bolivia. His home address is 503 West 14th Street, Little Rock, Arkansas.

DAVID M. GRUBBS, formerly with the Shell Oil Company, Inc., is now with the Danciger Oil and Refining Company, Fort Worth, Texas.

FOSTER M. MONAHAN has left Jones and Laughlin, Tulsa. He is a geologist in the employ of the Stanolind Oil and Gas Company, Midland, Texas.

KARL H. SCHMIDT has left the Arkansas Fuel Oil Company, Shreveport, Louisiana, and has gone into private business as a geological engineer with V. T. Donnelly, at San Antonio, Texas, Alamo National Bank Building, doing core analysis, bottomhole sampling and analysis, and general petroleum engineering.

KENNETH E. CASTER, of the University of Cincinnati, is the author of "A New Jellyfish (*Kirklandia texana* Caster) from the Lower Cretaceous of Texas," published as No. 18 of Vol. III of *Palaeontographica Americana* (Palaeontological Research Institution, Ithaca, New York, March 15, 1945). There are 52 pages, 8 figures, and 5 full-tone plates.

FIELD CONFERENCE ON ELLENBURGER STRATA, LLANO REGION, TEXAS

(June 15-23)

Geologists interested in the stratigraphy of the Ellenburger rocks are invited to participate in a field review of exposures in central Texas, to be conducted by geologists of the Bureau of Economic Geology, University of Texas and the Geological Survey, United States Department of the Interior.

It is planned that an illustrated introductory discussion be given on the evening of Thursday, June 14, in the auditorium of the Geology Building on the campus of the University of Texas. This discussion will be supplemented by displays of sequentially arranged rock samples from representative sections. The field conference will consist of two parts as here noted.

Part 1.—June 15 and 16 (Friday and Saturday) will be devoted to a review in the field of measured sections that will display the entire sequence of the Ellenburger strata at the surface, as well as some related rocks. Headquarters will be at Austin and the number of conferees will be limited only by Austin's rooming accommodations and your own transportation facilities. No notification need be given by those planning to attend the first two days of the trip (June 15 and 16). Simply arrange your own transportation and obtain hotel accommodations in Austin for the nights of June 14 and 15.

Part 2.—From June 17 to 23 other measured sections of the Ellenburger will be visited. Local accommodations will limit the number of conferees on this part of the trip and arrangement must be specially made. It is, therefore, necessary that those wishing to attend the second part of the field conference (June 17 to 23) notify the Bureau of Economic Geology, University of Texas before June 1 so that arrangements may be made for local accommodations in the Llano region.

Preliminary papers on the Ellenburger and related rocks are now in press and will be published before the conference. Such additional information as will be needed to enable individual conferees to follow the field tour will be distributed in mimeographed form at Austin when the conference assembles.

Following are some of the principal hotels and autocourts in Austin. As most of the autocourts will require a deposit before they will make reservations, it is recommended

that you begin making your arrangements at an early date. The autocourts in north Austin are the most convenient to the University and for the first days field work. Those in south Austin are convenient for the second days field work. All the hotels named are in downtown Austin.

Hotels

Stephen F. Austin
Driskill
Texas
Alamo

Autocourts in North Austin

Longhorn Lodge
Travis Court
Petrified Forest
Cactus Court
Lamarr Motel

Autocourts in South Austin

Sam Houston Motel
San Jose Court
Austin Motel
Goodnight Courts
St. Elmotel

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The executive committee has approved for publication the names of the following candidates for membership in the Association. This does not constitute an election but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it promptly to the Executive Committee, Box 979, Tulsa 1, Oklahoma. (Names of sponsors are placed beneath the name of each nominee.)

FOR ACTIVE MEMBERSHIP

Frank Allison Bruner, Lake Charles, La.

R. A. Weingartner, Shirley L. Mason, Ray C. Lewis

Ian MacLaren Cook, Calgary, Alta., Canada

W. C. Howells, J. G. Spratt, Henry Carter Rea

Earling Lester Erickson, Los Angeles, Calif.

R. M. Barnes, Glenn H. Bowes, John N. Huber

Ralph Evans, Houston, Tex.

Willard L. Miller, A. I. Levorsen, C. G. Lalicker

George Camille Felix Greant, Cairo, Egypt

William S. Wallis, E. L. Estabrook, G. M. Knebel

Wilber Eugene Greenman, Corpus Christi, Tex.

John C. Miller, W. W. Patrick, George H. Clark

Wilbert Henry Hass, Washington, D. C.

Hugh D. Miser, John B. Reeside, Jr., Lloyd G. Henbest

Jesse Duff Hatch, Jr., Midland, Tex.

V. C. Maley, William B. Hoover, Theodore S. Jones

Margaret Hayward Hawn, Evansville, Ind.

Kenneth A. Simmons, Frederick T. Jensen, Clifford G. Hardin

Herman Henry Kaveler, Bartlesville, Okla.

G. R. Elliott, R. G. Moss, Harris H. Allen

Kenneth W. Lewis, Evansville, Ind.

Kenneth A. Simmons, Clifford G. Hardin, Frederick T. Jensen

John B. Means, Jr., Jackson, Miss.

K. A. Schmidt, S. G. Gray, K. K. Spooner

William Arthur Milek, Casper, Wyo.

Raymond M. Larsen, John R. Schwabrow, Paul T. Walton

Donald O. Nelson, Bogota, Colombia, S. A.

Donald McArthur, R. B. Wheeler, W. C. Hatfield

Edgar A. Rassiniere, Bartlesville, Okla.

G. R. Elliott, R. G. Moss, Homer H. Charles

William H. Thomas, Los Angeles, Calif.

Alex Clark, John B. Sansone, Harold B. Rathwell

Charles Calvin Toomey, Tulsa, Okla.

John W. Merritt, H. W. Peabody, Charles F. Hewett

John Gaul Watson, Shreveport, La.

G. D. Thomas, D. W. St. Clair, G. E. Tash

Thomas James Weaver, Grand Rapids, Mich.

R. B. Newcombe, Max W. Ball, Edward J. Baltrusaitis

Harry Max Whaley, Ventura, Calif.

C. E. Leach, A. S. Holston, Robert Lindsey

Edwin Lewis Wilkins, Natchez, Miss.

Frederic F. Mellen, Carl F. Grubb, C. L. Morgan

FOR ASSOCIATE MEMBERSHIP

Robert William Biggart, Wichita, Kan.

Thomas N. Roberts, G. M. Kridler, W. F. Bowser

Margaret Delano Binkley, Taft, Calif.

J. David Cerkel, Jr., Edward J. Coenen, Burton R. Ellison

Virginia Jackson Cox, Fort Worth, Tex.

C. D. Cordry, M. E. Upson, E. H. Powers

Ross Walter Craig, Casper, Wyo.

M. D. Hubley, W. S. McCabe, George R. Wood

James Gordon Creed, Los Angeles, Calif.

Frank Parker, William W. Porter, II, R. W. Clark

Donald Lee Graf, Golden, Colo.

F. M. Van Tuyl, J. Harlan Johnson, Ben H. Parker

William Reginald Higgs, Brandon, Miss.

T. G. Andrews, E. F. Richards, R. W. Beck

Arthur M. Hull, Galveston, Tex.

S. W. Lowman, W. S. Adkins, Marcus A. Hanna

Arthur A. Seeligson, Jr., San Antonio, Tex.

Raymond F. Kravis, Wesley G. Gish, Don O. Chapell

Raymond Harold Swanson, San Francisco, Calif.

Dollie Radler Hall, John L. Ferguson, J. F. Hosterman

Otto van Rossum, Tampico, Tamps., Mexico

Ben C. Belt, M. H. Steig, William A. Baker, Jr.

Wallace Woodrow Wilson, Bradford, Pa.

M. G. Gulley, Maynard M. Stephens, A. O. Woodford

W. Ford Young, Bogota, Colombia, S. A.

Edward S. Bleecker, Paul H. Boots, John F. Barrett

FOR TRANSFER TO ACTIVE MEMBERSHIP

Robert Osborn Dunbar, Bartlesville, Okla.

Horace D. Thomas, A. J. Hintze, W. H. Courtier

William R. Farley, Sulphur, La.

Harry Kilian, Leslie Bowling, W. R. Canada

Hiram Darby Hand, Saginaw, Mich.

Clinton Engstrand, Edward J. Baltrusaitis, Jed B. Maebius

Fred Hubert Latimer, Evansville, Ind.

C. W. Wilson, Ralph Esarey, Stanley G. Elder

Norval Wallace Nichols, Calgary, Alta., Canada

A. R. May, Kenneth L. Gow, Maria Spencer

Charles Edwin Mohler, Rogers, Ark.

V. E. Monnett, C. E. Decker, C. G. Lalicker

Archibald Balfour Patterson, Dallas, Tex.

Melvin M. Garrett, Vernon E. Autry, George B. Stone

Harold H. Sullwold, Jr., Los Angeles, Calif.

U. S. Grant, IV, James Gilluly, Frank S. Parker

Robert L. Tucker, Jr., Dallas, Tex.

J. C. Menefee, Paul E. Nash, Henry C. Cortes

DISTINGUISHED LECTURE TOUR

The final lecture in the 1944-45 series, sponsored by the distinguished lecture committee, was given by FRED M. BULLARD, professor of geology at the University of Texas, Austin, Texas, on the subject "Paricutin—Mexico's Newest Volcano." Bullard presented the results of his observations of the volcano's activities during the summer and autumn of 1944 and his talk was suitably illustrated by a splendid series of colored motion pictures and slides. Because of the general interest in the volcano's inception and growth, many of the societies used this opportunity to bring geology more forcefully before the public and opened their meetings to all who wished to attend.

Bullard appeared before the following groups in the course of his tour.

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| April | 12 | North Texas Geological Society at Wichita Falls |
| | 13 | Dallas Petroleum Geologists at Dallas |
| | 14 | East Texas Geological Society at Tyler |
| | 20 | West Texas Geological Society at Midland |
| | 23 | Pacific Section AAPG at Los Angeles |
| | 24 | San Joaquin Geological Society at Bakersfield |
| | 25 | Northern California Geological Society at Sacramento |
| | 27 | University of Washington at Seattle |
| | 30 | Alberta Geological Society at Calgary |
| May | 2 | Wyoming Geological Association at Casper |
| | 4 | Rocky Mountain Association of Petroleum Geologists at Denver |
| | 5 | Colorado College at Colorado Springs |
| | 7 | Kansas Geological Society at Wichita |
| | 8 | Shawnee Geological Society at Shawnee |
| | 9 | Tulsa Geological Society at Tulsa |
| | 11 | Illinois and Indiana-Kentucky Geological Societies at Olney |
| | 12 | University of Iowa at Iowa City |
| | 14 | Oklahoma City Geological Society at Oklahoma City |
| | 15 | Fort Worth Geological Society at Fort Worth |

JOHN L. FERGUSON, *chairman*

VINCENT CHARLES ILLING, professor geology at the Imperial College of Mines and Technology, London, has been nominated to become a member of the Royal Society. Illing read a paper on "The Role of Stratigraphy in Oil Discovery," at an informal dinner sponsored by the Tulsa Geological Society, at the Tulsa Club, on March 27, in honor of the officers and business committee of the Association, at the time of the thirtieth annual meeting of the Association.

JOHN O. NIGRA has left the Chanslor-Canfield Midway Oil Company to accept an assignment with the General Petroleum Corporation, Los Angeles, California.

New officers of the Indiana-Kentucky Geological Society of Evansville, Indiana, are: president, STANLEY G. ELDER, Sun Oil Company; vice-president, HILLARD W. BODKIN, Superior Oil Company; secretary-treasurer, JESS H. HENGST, Barnsdall Oil Company. New members of the executive committee are: J. ALBERT BROWN, Sohio Producing Company, and KENNETH LEMAY CHASEY, The Texas Company.

GEORGE E. DORSEY has transferred from the Alaskan Branch of the United States Geological Survey to the Foreign Production Division of the Petroleum Administration for War, new Interior Building, Washington 25, D. C.

The Mississippi Geological Society held a symposium on the Upper Cretaceous of Mississippi, April 27, at the Edwards Hotel in Jackson. Speakers were ROY T. HAZZARD, geologist of the Gulf Refining Company, Shreveport, Louisiana; L. W. STEPHENSON, United States Geological Survey, Washington, D. C.; J. B. WHEELER, Stanolind Oil and Gas Company, Jackson, Mississippi; EDWARD C. CRAM, Magnolia Petroleum Company, Jackson, Mississippi; WATSON H. MONROE, United States Geological Survey, Tuscaloosa, Alabama; and D. H. EARGLE, United States Geological Survey, Tuscaloosa, Alabama. Approximately 150 geologists and geophysicists were present. President L. R. MCFARLAND turned the meeting over to JULES BRAUNSTEIN, chairman of the Cretaceous committee, who presided over the symposium.

The Mississippi Geological Society has released a new Geologic Map of Mississippi in colors on a scale of 1:500,000. This map shows the boundaries of surface formations and a number of the larger known surface faults, and is a compilation of the field maps of oil companies and independents, checked in the field by geologists of the United States Geological Survey. The Tertiary Committee of the Society has recently released a correlation chart for the Tertiary of Mississippi and Alabama. The map and the chart may be ordered from FREDERIC F. MELLEN, secretary-treasurer, Mississippi Geological Society, c/o Mellen & Monsour, consulting geologists, 112½ E. Capitol Street, Jackson, Mississippi. The price of the map is \$3.00 plus 25 cents for mailing; the price of the chart is 50 cents plus 5 cents postage.

The Mississippi Geological Society is sponsoring a geological library to be housed temporarily in the Jackson Public Library. A number of periodicals have been subscribed to, and technical books have been purchased. In addition, loans and donations are being received. Anyone wishing to contribute to this library on a loan or a gift basis is requested to communicate with L. C. DENNIS, chairman, Library Committee, Mississippi Geological Society, c/o Pure Oil Company, Tower Building, Jackson, Mississippi.

FREDERIC F. MELLEN and E. T. ("MIKE") MONSOUR have opened consulting offices at 112½ East Capitol Street, Jackson, Mississippi. Mellen was formerly district geologist of the British-American Oil Producing Company, and Monsour was paleontologist and stratigrapher for the Standard Oil Company (New Jersey) and the Humble Oil and Refining Company. He later worked for the Navarro Oil Company in Mississippi.

An oil industry committee of five appointed committees last month to prepare data for the oil industry's presentation at the hearings of the special Petroleum Committee of the Senate, of which Senator Joseph C. O'Mahoney is chairman. The hearings were opened, May 17, at Washington, D. C., to aid the committee in developing a national oil policy. One of the appointments is the committee on sources of petroleum supply:

JOHN M. LOVEJOY, chairman, Seaboard Oil Company of Delaware, Inc., New York
E. BUDDRUS, Independent Natural Gas Association, Chicago
E. DEGOLYER, Dallas
JAMES TERRY DUCE, Arabian American Oil Company, San Francisco
W. H. FERGUSON, Continental Oil Company, Denver
WALTER S. HALLANAN, Plymouth Oil Company, Pittsburgh
GEORGE A. HILL, Jr., Houston Oil Company, Houston
J. C. HUNTER, Mid-Continent Oil and Gas Association, Washington, D. C.
A. I. LEVORSEN, Tulsa
RALPH B. LLOYD, Western Oil and Gas Association, Los Angeles
A. C. MATTEI, Honolulu Oil Corporation, San Francisco
J. EDGAR PEW, Sun Oil Company, Philadelphia

HENRY PHILLIPS, Sinclair Oil Corporation, New York
J. FRENCH ROBINSON, American Gas Association, Cleveland
CHARLES F. ROESER, Roeser & Pendleton, Fort Worth
R. S. SHANNON, Pioneer Oil Corporation, Denver
GEORGE S. WALDEN, Standard-Vacuum Company, Inc., New York
HENRY C. WEISS, Humble Oil and Refining Company, Houston
RALPH T. ZOOK, Independent Petroleum Association of America, Bradford

EVERETT S. SHAW is engaged in consulting work. His address is 3131 Zenobia Street, Denver, Colorado.

Captain JAMES E. WILSON has joined the staff and faculty at the Command and General Staff School at Fort Leavenworth. His address is C & G SS, 633-5 McClellan Avenue, Fort Leavenworth, Kansas. He was formerly at Rockdale, Texas.

L. W. FOLSOM has left his position as assistant geologist with the West Virginia Geological Survey to accept employment with The California Company, Lexington, Kentucky.

The committee on tectonics, of the Division of Geology and Geography, National Research Council is continuing to function. Anyone having corrections to be made on the *Tectonic Map of the United States*, recently published by the A.A.P.G., is requested to write to CHESTER R. LONGWELL, chairman of the committee, Department of Geology, Yale University, New Haven, Connecticut, or to PHILIP B. KING, vice-chairman, United States Geological Survey, Washington 25, D. C.

HAROLD BEACH GOODRICH, consulting geologist, died at his home in Tulsa, April 25, at the age of 75 years. The cause of death was an attack of bronchial asthma. Goodrich joined the Association in 1918 and was elected an honorary member in 1929 in recognition of his long and honorable activity in the profession of petroleum geology and particularly his faithful and valuable service in the Association.

JAMES R. DORRANCE, of The Texas Company, was recently appointed division geologist in charge of the Pacific Coast region with headquarters in Los Angeles. He was formerly located in Bakersfield, California, where he was doing general geological research work.

MILTON W. LEWIS, formerly with WALKER S. CLUTE, is now engaged in consulting petroleum geology and valuation engineering, with offices in the Petroleum Building, 714 West Olympic Boulevard, Room 906, Los Angeles 15, California.

FLOYD C. MERRITT, of the Byron Jackson Company, Los Angeles, California, has been elected a vice-president of the company. Merritt was with J. E. ELLIOTT of the Elliott Core Drilling Company from 1922 to 1939 when that company was acquired by the Byron Jackson Company.

ROGER HENQUET has been elected vice-president and general manager of the Schlumberger Well Surveying Corporation, Houston, Texas. Henquet was recently released from army service.

HARRY J. BROWN, independent operator of Tulsa, Oklahoma, died, April 7, at the age of 52 years.

A. J. CROWLEY, of the United States Geological Survey, located at Fort Worth, Texas, spoke on "Beds of Ellenburger Age in North-Central Texas," at a meeting of the Tulsa Geological Society, April 16, at Kendall Hall, University of Tulsa.

The South Texas Section of the Association has elected the following officers for the new administrative year: president, HARVEY WHITAKER, independent, 1409 Milam Building; vice-president, GEORGE H. COATES, independent, 638 Milam Building; secretary-treasurer, MARION J. MOORE, Transwestern Oil Company, 1600 Milam Building; HAROLD D. HERNDON, Saltmount Oil Company, 915 Milam Building; all of San Antonio, Texas. Luncheon and program are held every Monday noon at the Milam Cafeteria. Special night meetings will be announced.

PAUL CHARRIN, former vice-president and general manager of the Schlumberger Well Surveying Corporation, is opening an office, as an independent geophysical consultant and engineer, at 913 Union National Bank Building, Houston 2, Texas. He was with the Schlumberger organization for almost 20 years.

The Rocky Mountain Association of Petroleum Geologists, Denver, Colorado, in regular meeting Thursday, April 26, at the Cosmopolitan Hotel, heard C. E. DOBBIN, of the United States Geological Survey, discuss "The Cretaceous-Tertiary Contact in the Northern Great Plains."

The Houston Geological Society held a regular meeting Thursday, April 19, on the mezzanine floor of the Texas State Hotel. J. B. STONE, of Dowell, Inc., spoke on "The Use of Plastics in Oil and Gas Wells." On May 3, E. H. SELLARDS, director of the Bureau of Economic Geology, at Austin, talked on "The Mineral Resources of Texas."

T. E. SWIGART, president of the Shell Pipe Line Company, addressed the 4th Industrial Planning Conference on Power Resources recently. His subject was "Oil Pipe Lines." W. T. THOM, JR., professor and chairman of the department of geological engineering, Princeton University, addressed the conference on the subject of "Energy Resources and National Power." The conference was held recently at the University of Texas, Austin, Texas.

Captain ALFRED R. LOEBLICH, JR., formerly of Tulane University, New Orleans, is somewhere in the Pacific theater. His address is A.P.O. 27, c/o Postmaster, San Francisco, California. Mrs. HELEN N. LOEBLICH is at 452 College, Norman, Oklahoma, for the duration.

The Houston Geological Society held a special meeting on April 27, at 7:45 P.M. in the Houston Public Library. W. R. CANADA, of Magnolia Petroleum Company, presented "A Progress Report by the Geologic Names and Correlation Committee of the South Louisiana Geological Society," dealing with the Eocene, Oligocene, and lower Miocene formations.

H. C. ARNOLD, has resigned as vice-president and general manager of the British-American Oil Producing Company to become vice-president and head of oil and gas exploration for the Ashland Oil and Refining Company, Tulsa, Oklahoma. THAD C. HOKE, chief geologist of the British-American, is now manager of the geological department.

JOHN M. NISBET has resigned his positions as vice-president and manager of the land and geological division of the Cities Service Oil Company, Bartlesville, Oklahoma. ROBERT L. KIDD succeeds Nisbet as manager of the division. A. K. WILHELM succeeds Kidd as chief geologist.

PROFESSIONAL DIRECTORY

CALIFORNIA

<p>J. L. CHASE <i>Geologist — Geophysicist</i> 529 East Roosevelt Road LONG BEACH CALIFORNIA <i>Specializing in Magnetic Surveys</i></p>	<p>PAUL P. GOUDKOFF <i>Geologist</i> Geologic Correlation by Foraminifera and Mineral Grains 799 Subway Terminal Building LOS ANGELES, CALIFORNIA</p>
<p>VERNON L. KING <i>Petroleum Geologist and Engineer</i> 707 South Hill Street LOS ANGELES, CALIFORNIA Vandike 7087</p>	<p>JEROME J. O'BRIEN <i>Petroleum Geologist</i> Examinations, Reports, Appraisals Petroleum Building 714 West Olympic Boulevard MCCARTHY & O'BRIEN Los Angeles 15, Calif.</p>
<p>ERNEST K. PARKS <i>Consultant in</i> <i>Petroleum and Natural Gas Development</i> <i>and</i> <i>Engineering Management</i> 614 S. Hope St. LOS ANGELES, CALIFORNIA</p>	<p>HENRY SALVATORI <i>Western Geophysical Company</i> 711 Edison Building 601 West Fifth Street LOS ANGELES, CALIFORNIA</p>
<p>RICHARD L. TRIPLETT <i>Core Drilling Contractor</i> Whitney 9876 2013 West View St. LOS ANGELES 16, CALIF.</p>	

COLORADO

<p>C. A. HEILAND <i>Heiland Research Corporation</i> 130 East Fifth Avenue DENVER, 9, COLORADO</p>	<p>HARRY W. OBORENE <i>Geologist</i> 304 Mining Exchange Bldg. 230 Park Ave. Colorado Springs, Colo. New York, N.Y. Main 7525 Murray Hill 9-3341</p>
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ILLINOIS

<p>CLARENCE E. BREHM <i>Geologist and Geophysicist</i> Box 502, Mt. Vernon, Illinois 725 Magnolia Ave. Phone 1643</p>	<p>ELMER W. ELLSWORTH <i>Consulting Geologist</i> 201 Grand Theatre Building 132 North Locust Street CENTRALIA, ILLINOIS <i>Now in military service</i></p>
<p>L. A. MYLIUS <i>Geologist Engineer</i> 132 North Locust Street Box 264, Centralia, Illinois</p>	<p>T. E. WALL <i>Geologist</i> Mt. Vernon Illinois</p>

INDIANA		LOUISIANA	
HARRY H. NOWLAN Consulting Geologist and Engineer Specializing in Valuations Evansville 19, Indiana 317 Court Bldg. Phone 2-7817		WILLIAM M. BARRET, INC. Consulting Geophysicists Specializing in Magnetic Surveys Giddens-Lane Building SHREVEPORT, LA.	
MISSISSIPPI			
G. JEFFREYS Geologist Engineer Specialist, Mississippi & Alabama 100 East Pearl Street Box 2415 Depot P.O. Jackson, Mississippi		MELLEN & MONSOUR Consulting Geologists Frederic F. Mellen E. T. "Mike" Monsour Box 2571, West Jackson, Mississippi 112½ E. Capitol St. Phone 2-1368	
NEW YORK			
BROKAW, DIXON & McKEE Geologists Engineers OIL—NATURAL GAS Examinations, Reports, Appraisals Estimates of Reserves 120 Broadway New York Gulf Building Houston		BASIL B. ZAVOICO Petroleum Geologist and Engineer 220 East 42nd Street NEW YORK 17, NEW YORK Murray Hill 2-6750	
NORTH CAROLINA		OHIO	
RODERICK A. STAMEY Petroleum Geologist 109 East Gordon Street KINSTON NORTH CAROLINA		JOHN L. RICH Geologist Specializing in extension of "shoestring" pools University of Cincinnati Cincinnati, Ohio	
OKLAHOMA			
ELFRED BECK Geologist 308 Tulsa Loan Bldg. Box 55 TULSA, OKLA. DALLAS, TEX.		FRANK BRYAN Consulting Geologist NELSON OKLAHOMA	
R. W. Laughlin L. D. Simmons WELL ELEVATIONS LAUGHLIN-SIMMONS & CO. 615 Oklahoma Building TULSA OKLAHOMA		A. I. LEVORSEN Petroleum Geologist 221 Woodward Boulevard TULSA 5 OKLAHOMA	

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IN 1944

by

F. M. VAN TUYL AND W. S. LEVINGS

With the cooperation of members of the staffs of the Departments of Geology, Geophysics, and Petroleum Engineering of the Colorado School of Mines

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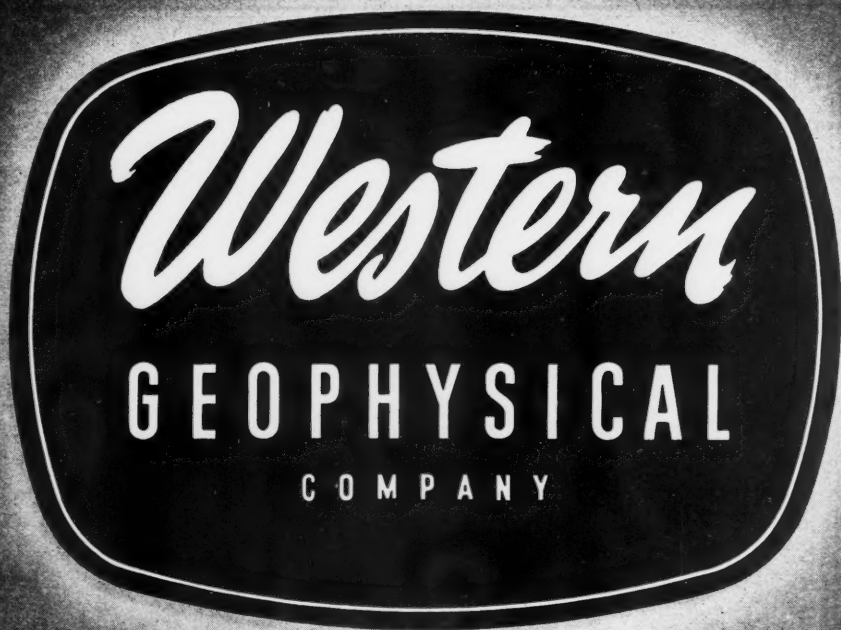
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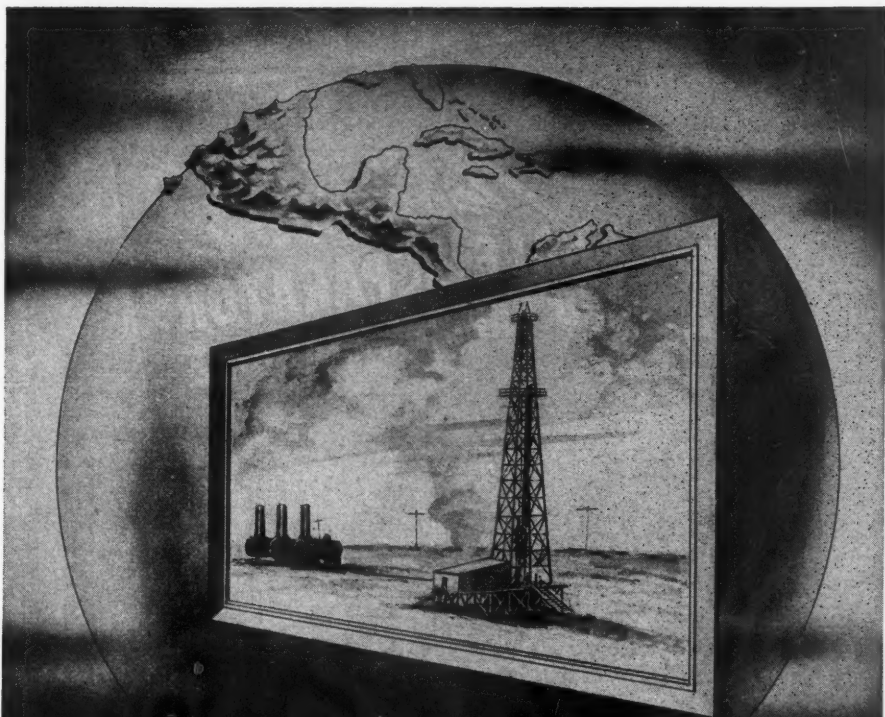
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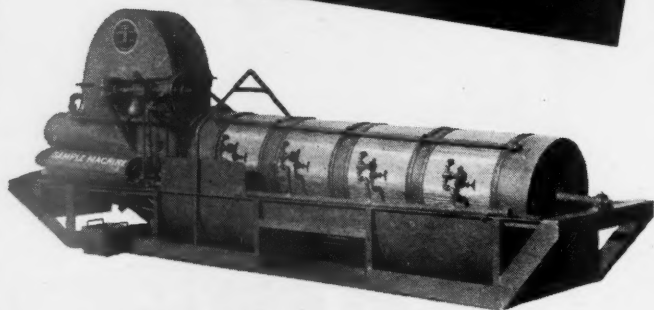
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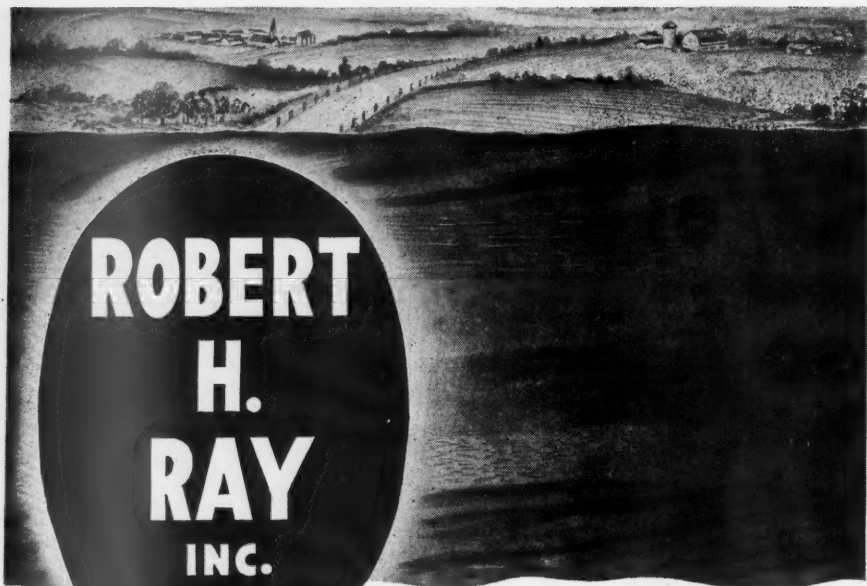
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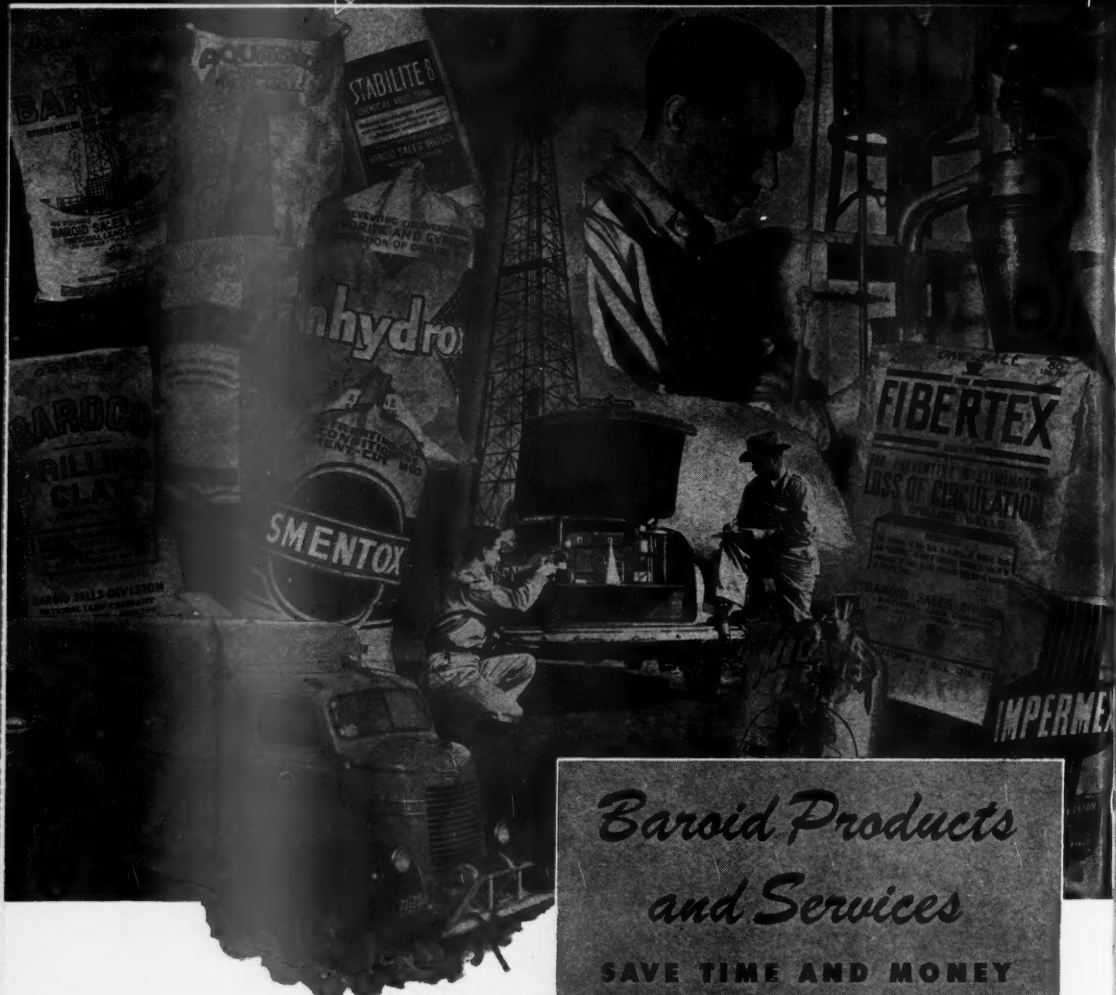
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